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MONITORING AND EVALUATION OF SMOLT MIGRATION IN THE COLUMBIA BASIN VOLUME VI

Evaluation of the 2000 Predictions of the Run-Timing of Wild Migrant Chinook Salmon & Steelhead Trout, & Hatchery Sockeye Salmon in the Snake River Basin, & Combined Wild & Hatchery Salmonids migrating to Rock Island & McNary Dams Using Program RealTime

Technical Report 2000

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Volume II: Townsend, R. L., J. R. Skalski, and D. Yasuda. 1998. Evaluation of the 1996 predictions of run-timing of wild migrant subyearling chinook in the Snake River Basin using program RealTime. Technical Report (DOE/BP-91572-2) to BPA, Project 91-051-00, Contract 91-BI-91572.

Volume III: Townsend, R. L., J. R. Skalski, and D. Yasuda. 2000. Evaluation of the 1997 predictions of run-timing of wild migrant yearling and subyearling chinook and sockye in the Snake River Basin using program RealTime. Technical Report (accepted) to BPA, Project 91-051-00, Contract 91-BI-91572.

Volume IV: Burgess,C., R. L. Townsend, J..R. Skalski, and D. Yasuda. 2000. Evaluation of the 1998 predictions of the run-timing of wild migrant yearling and subyearling chinook and steelhead, and hatchery sockeye in the Snake River Basin using program RealTime. Technical Report (submitted) to BPA, Project 91-051-00, Contract 96BI-91572.

Volume V: Burgess,C., J..R. Skalski. 2000. Evaluation of the 1999 predictions of the run-timing of wild migrant yearling and subyearling chinook salmon and steelhead trout, and hatchery sockeye salmon in the Snake River Basin using program RealTime. Technical Report (submitted) to BPA, Project 91-051-00, Contract 96BI-91572.

Other Publications Related to this Series

Other related publications, reports and papers available through the professional literature or from the Bonneville Power Administration (BPA) Public Information Center - CKPS-1, P.O. Box 3621, Portland, OR 97208.

<u>1997</u>

Townsend, R. L., D. Yasuda, and J. R. Skalski. 1997. Evaluation of the 1996 predictions of run timing of wild migrant spring/summer yearling chinook in the Snake River Basin using program RealTime. Technical Report (DOE/BP-91572-1) to BPA, Project 91-051-00, Contract 91-BI-91572.

<u>1996</u>

Townsend, R. L., P. Westhagen, D. Yasuda, J. R. Skalski, and K. Ryding. 1996. Evaluation of the 1995 predictions of run timing of wild migrant spring/summer yearling chinook in the Snake River Basin using program RealTime. Technical Report (DOE/BP-

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1995

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1994

Skalski, J. R., G. Tartakovsky, S. G. Smith, P. Westhagen, and A. E. Giorgi. 1994. Pre-1994 season projection of run-timing capabilities using PIT-tag databases. Technical Report (DOE/BP-35885-7) to BPA, Project 91-051-00, Contract 87-BI-35885.

1993

Skalski, J. R., and A. E. Giorgi. 1993. A plan for estimating smolt travel time and survival in the Snake and Columbia Rivers. Technical Report (DOE/BP-35885-3) to BPA, Project 91-051-00, Contract 87-BI-35885.

Smith, S. G., J. R. Skalski, and A. E. Giorgi. 1993. Statistical evaluation of travel time estimation based on data from freeze-branded chinook salmon on the Snake River, 1982-1990. Technical Report (DOE/BP-35885-4) to BPA, Project 91-051-00, Contract 87-BI-35885.

Preface

Project 91-051 was initiated in response to the Endangered Species Act (ESA) and the subsequent 1994 Council Fish and Wildlife Program (FWP) call for regional analytical methods for monitoring and evaluation. This project supports the need to have the "best available" scientific information accessible to the BPA, fisheries community, decision-makers, and public by analyzing historical tagging data to investigate smolt outmigration dynamics, salmonid life histories and productivity, and providing real-time analysis to monitor outmigration timing for use in water management and fish operations of the hydrosystem. Primary objectives and management implications of this project include: (1) to address the need for further synthesis of historical tagging and other biological information to improve understanding and identify future research and analysis needs; (2) to assist in the development of improved monitoring capabilities, statistical methodologies and software tools to aid management in optimizing operational and fish passage strategies to maximize the protection and survival of listed threatened and endangered Snake River salmon populations and other listed and nonlisted stocks in the Columbia River Basin; (3) to design better analysis tools for evaluation programs; and (4) to provide statistical support to the Bonneville Power Administration and the Northwest fisheries community.

The following report addresses measure 4.3C of the 1994 Northwest Power Planning Council's Fish and Wildlife Program with emphasis on improved monitoring and evaluation of smolt migration in the Columbia River Basin. This report represents the tenth in a series of technical reports presenting results of applications of statistical program RealTime to present in-season predictions of the status of smolt migrations in the Columbia River Basin. Results and evaluation of program RealTime 2000 predictions of the run-timing of wild migrant chinook salmon and steelhead trout, and hatchery-reared sockeye salmon in the Snake River Basin, and combined wild and hatchery salmonids migrating to Rock Island and McNary Dams are presented. It is hoped that making these real-time predictions and supporting data available on the Internet for use by the Technical Management Team (TMT) and members of the fisheries community will contribute to effective in-season population monitoring and assist in-season management of river and fisheries resources. Having the capability to more accurately predict smolt outmigration status improves the ability to match flow augmentation to the migration timing of

ESA listed and other salmonid stocks and also contributes to the regional goal of increasing juvenile passage survival through the Columbia River system.

ABSTRACT

Program RealTime provided tracking and forecasting of the 2000 inseason outmigration via the internet for stocks of wild PIT-tagged spring/summer chinook salmon. These stocks were ESUs from nineteen release sites above Lower Granite dam, including Bear Valley Creek, Big Creek, Camas Creek (new), Cape Horn Creek, Catherine Creek, Elk Creek, Herd Creek, Imnaha River, Johnson Creek (new), Lake Creek, Loon Creek, Lostine River, Marsh Creek, Minam River, East Fork Salmon River (new), South Fork Salmon River, Secesh River, Sulfur Creek and Valley Creek. Forecasts were also provided for two stocks of hatchery-reared PIT-tagged summer-run sockeye salmon, from Redfish Lake and Alturas Lake (new); for a subpopulation of the PIT-tagged wild Snake River fall subyearling chinook salmon; for all wild Snake River PIT-tagged spring/summer yearling chinook salmon (new) and steelhead trout (new)detected at Lower Granite Dam during the 2000 outmigration. The 2000 RealTime project began making forecasts for combined wild- and hatchery-reared runs-at-large of subyearling and yealring chinook, coho, and sockeye salmon, and steelhead trout migrating to Rock Island and McNary Dams on the mid-Columbia River and the mainstem Columbia River. Due to the new (in 1999-2000) Snake River basin hatchery protocol of releasing unmarked hatchery-reared fish, the RealTime forecasting project no longer makes run-timing forecasts for wild Snake River runs-at-large using FPC passage indices, as it has done for the previous three years (1997-1999).

The season-wide measure of Program RealTime performance, the mean absolute difference (MAD) between in-season predictions and true (observed) passage percentiles, improved relative to previous years for nearly all stocks. The average season-wide MAD of all (nineteen) spring/summer yearling chinook salmon ESUs dropped from 5.7% in 1999 to 4.5% in 2000. The 2000 MAD for the hatchery-reared Redfish Lake sockeye salmon ESU was the lowest recorded, at 6.0%, down from 6.7% in 1999. The MAD for the PIT-tagged ESU of wild Snake River fall subyearling chinook salmon, after its second season of run-timing forecasting, was 4.7% in 2000 compared to 5.5% in 1999. The high accuracy of season-wide performance in 2000 was largely due to exceptional Program RealTime performance in the last half of the season. Passage predictions from fifteen of the sixteen spring/summer yearling chinook salmon ESUs available for comparison improved in 2000 compared to 1999. The last-half average MAD over all the yearling chinook salmon ESUs was 4.3% in 2000, compared to 6.5% in 1999. Program RealTime 2000

first-half forecasting performance was slightly worse than that of 1999 (MAD = 4.5%), but still comparable to previous years with a MAD equal to 5.1%. Three yearling chinook ESUs showed moderately large (> 10%) MADs. These stocks had larger-than-average recapture percentages in 2000, producing over-predictions early in the season, in a dynamic reminiscent of migration year 1998 (Burgess et al., 1999).

The passage distribution of the new stock of hatchery-reared sockeye salmon from Alturas Lake was well-predicted by Program RealTime, based on only two years of historical data (whole-season MAD = 4.3%). The two new run-of-the-river PIT-tagged stocks of wild yearling chinook salmon and steelhead trout were predicted with very good accuracy (whole-season MADs were 4.8% for steelhead trout and 1.7% for yearling chinook salmon), particularly during the last half of the outmigration. First-half steelhead predictions were among the season's worst (MAD = 10.8%), with over-predictions attibutable to the largest passage on record of wild PIT-tagged steelhead trout to Lower Granite Dam. The results of RealTime predictions of passage percentiles of combined wild and hatchery-reared salmonids to Rock Island and McNary were mixed. Some of these passage-indexed runs-at-large were predicted with exceptional accuracy (whole-season MADs for coho salmon outmigrating to Rock Island Dam and McNary Dam were, respectively, 0.58% and 1.24%; for yearling chinook to McNary, 0.59%) while others were not forecast well at all (first-half MADs of sockeye salmon migrating to Rock Island and McNary Dams, respectively, were 19.25% and 12.78%). The worst performances for these mid- and main-stem- Columbia River runs-at-large were probably due to large hatchery release disturbing the smoothly accumulating percentages of normal fish passage.

The RealTime project used a stock-specific method of upwardly adjusting PIT-tagged smolt counts at Lower Granite Dam. For chinook and sockeye salmon, the project continued using the 1999 formulation for spill-adjustment. For the new stock of wild PIT-tagged steelhead trout, a formula derived for steelhead trout only was used.

The inclusion of five new PIT-tagged stocks and ten new passage-indexed stocks, and the discontinuance of forecasting passage-indexed wild runs-at-large at Lower Granite Dam were the noteworthy changes to the 2000 RealTime forecasting project, compared to previous years. No unusual trends or patterns in run-timing characteristics or run sizes were observed during migration year 2000.

Executive Summary

2000 Objectives

1. Refine application of program RealTime to improve precision and accuracy of in-season predictions of the run-timing of the wild Snake River subyearling and yearling chinook salmon and steelhead trout, and hatchery-reared sockeye salmon at Lower Granite Dam; refine application of program RealTime to improve precision and accuracy of in-season predictions of the run-timing of the combined wild and hatchery-reared mid-Columbia and Columbia River runs-at-large of subyearling and yearling chinook, coho and sockeye salmon, and steelhead trout at Rock Island and McNary Dams.
2. Predict and report in real-time the "percent run-to-date" and "date to specified percentiles" of the outmigrations at Lower Granite Dam, Rock Island Dam, and McNary Dam based on the Fish Passage Center's (FPC) passage indices and PIT-tag detections from specific release sites.
3. Post on-line Internet-based predictions on outmigration status and trends to improve in-season population monitoring information available for use by the Technical Management Team and the fisheries community to assist river management.

Accomplishments

The RealTime 2000 project tracked and forecasted a total of 19 wild PIT-tagged Snake River spring/summer yearling chinook salmon ESUs. Of these, 12 met RealTime's historical data requirements. These twelve include Bear Valley Creek, Big Creek, Catherine Creek, Elk Creek, Imnaha River, Lake Creek, Lostine River, Marsh Creek, Minam River, East Fork Salmon River, South Fork Salmon River, and Secesh River. As in previous years, ESUs which did not meet data requirements (Camas Creek, Cape Horn Creek, Herd Creek, Johnson Creek, Loon Creek, Sulfur Creek, and Valley Creek) were included in the RealTime project for the dual purpose of providing maximum run-timing information on ESU stocks and continuing to test whether release sites with less data nevertheless provide good predictions. New hatchery protocols which result in the release of unmarked hatchery fish into the Snake River have continued from 1999, and have extended to all salmonid species. To provide run-timing information on the discontinued runs-at-large previously tracked using FPC passage indices, the RealTime forecasting project has continued its tracking and forecasting of a PIT-tagged subpopulation of the fall subyearling chinook salmon run-at-large. In addition, two new PIT-tagged subpopulations were added to the project, to provide similar information on the yearling chinook salmon and steelhead trout runs-at-large. The objective of providing run-timing forecasts for hatchery-reared sockeye salmon from Redfish Lake based on PIT-tagged smolts was also accomplished in 2000. In addition a new ESU stock of hatchery-reared sockeye salmon from Alturas Lake was added to the project. Passage indices provided by the Fish Passage Center at Rock Island Dam and McNary Dam were utilized by the RealTime project to forecast the combined wild and hatchery-reared subyearling and yearling chinook, coho, and sockeye salmon, and steelhead trout runs-at-large for the first time in 2000. On-line run-timing predictions were provided via the Internet at *http://www.cbr.washington.edu/crisprt* to the fisheries community throughout each smolt outmigration.

Raw counts of all PIT-tagged smolts at Lower Granite Dam were upwardly adjusted for spill using the 1999 formulation for chinook and sockeye salmon; and using a new formulation for steelhead trout, reflecting the different passage efficiences observed between different species of salmonids at hydroelectric projects.

A calibration procedure was developed for Program RealTime to study whether utilization of optimal switching parameters within the algorithm would improve performance. The switching parameters help govern the timing at which the algorithm switches from run-percentage-based predictions to pattern-based predictions (Burgess, et al., 1999, Burgess and Skalski, 2000a).

Findings

Program RealTime predictions for wild Snake River yearling chinook salmon ESUs improved in 2000 with respect to season-wide performance and performance during the last half of the outmigration. In spite of a slightly worse performance in the first half of the 2000 outmigration relative to 1999, twelve of the sixteen stocks available for comparison showed improvement over 1999 in season-wide predictive accuracy. (The mean absolute deviance[1] (MAD) of the daily predicted outmigration-percentage from the actual outmigration-percentage is used as measure of accuracy in this and all previous RealTime reports). The whole-season mean MAD (averaged

1.Mean absolute deviance is the average absolute difference between the predicted proportion and the observed proportion of the outmigration distribution, calculated over the days in the outmigration.

over all 19 sites) for these spring/summer chinook salmon ESU outmigrations was 4.5% in 2000 compared to 5.7% in 1999. The run of hatchery-reared Redfish Lake sockeye salmon showed record high performance in accuracy of prediction in 2000 (whole season MAD was 6.0% in 2000 compared to 6.7% in 1999). Run-timing of the PIT-tagged stock of fall subyearling chinook salmon was forecasted for the second consecutive year in 2000. RealTime performance was slightly worse compared to 1999, with nevertheless very good accuracy (whole season MAD=4.9% in 2000 compared to 4.7% in 1999). RealTime performances in forecasting run-timing for the new PIT-tagged stocks of yearling chinook and steelhead trout were also very good, with the full-season MAD for yearling chinook salmon at 1.7%, and for steelhead trout at 4.8%. Run-timing characteristics of RealTime-forecasted stocks were, for the most part, unremarkable and within the range of normal. However several spring/summer chinook salmon ESUs showed higher-than-average detection rates, and the steelhead trout PIT-tag count was the largest on record. For these stocks, we observed outmigration dynamics similar to 1998, when, without exception, chinook ESUs were over-predicted in the first half of the outmigration, the result of larger-than-expected runs. The runs-at-large of FPC passage indexed smolts to Rock Island Dam and McNary Dam were remarkably well predicted for some runs (to within 2% of the observed distribution for coho salmon migrating to both dams, and for yearling chinook migrating to McNary Dam), but poorly predicted for others (with MADs over 10% for sockeye salmon migrating to both dams, and subyearling chinook salmon and steelhead trout migrating to Rock Island Dam). Overall, performance was better for the runs forecasted to McNary Dam than to Rock Island Dam, reflecting the higher abundances of fish passing McNary compared to Rock Island. The worst performances were probably due to large hatchery releases disturbing the smooth cumulative percentage curves seen in normal fish passage.

A RealTime program calibration study revealed that use of optimal model-switching parameters results in significant predictive improvement for many stocks (Burgess and Skalski, 2000b). Previously, the same model-switching parameters were used for all stocks.

Management Implications

The ability to accurately predict the outmigration status of composite or individual salmon and steelhead stocks at different locations in the Federal Columbia River Power System (FCRPS) can provide valuable information to assist water managers. Since the 1994 outmigration, program

RealTime has been applied to provide in-season predictions of smolt outmigration timing for individual and aggregates of listed threatened and endangered Snake River salmon stocks. These predictions have been made available to the fisheries community to assist in-season river management.

Recommendations

In order to maintain the high standards of performance observed in the 2000 RealTime forecasting project, it is recommended that we utilize the study results of a new calibration procedure developed for Program RealTime (Burgess and Skalski, 2000b) for the upcoming migration year 2001 RealTime forecasting project. The calibration procedure optimizes the model-switching dynamics of the RealTime algorithm for individual stocks (Burgess and Skalski, 2000a). The use of optimal model-switching parameters for each stock will likely improve 2001 predictions for individual ESUs as well as increase the likelihood of high performance for new stocks that need to be added to the project on short notice. In addition, Program RealTime will be re-calibrated each year in the future, and thereby incorporate the latest migration-year data into the historical record, in order to further increase accuracy.

We also recommend continuing to monitor and evaluate ongoing research into passage efficiencies at Lower Granite Dam and the effects of river variables on these passage fractions, in order to produce adjusted counts of raw smolts that most accurately reflect the true numbers of smolts passing Lower Granite dam in their seaward migrations.

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Special appreciation is extended to Chris Van Holmes, Susannah Iltis, and Peter Westhagen of the School of Fisheries at the University of Washington for providing critical data management and computer programming support.

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1.0 Introduction

Regulating the timing and volume of water released from storage reservoirs (often referred to as flow augmentation) has become a central mitigation strategy for improving downstream migration conditions for juvenile salmonids in the Columbia River Basin. Snake River and Upper Columbia River water managers have used flow augmentation to improve the outmigration survival of stocks listed as threatened or endangered under the Endangered Species Act (ESA). Timing the release of water so that the listed stocks are in place to encounter these augmented flows requires knowledge of the status and trend of the stocks' outmigration timing.

In 1993, work was begun under this project to develop real-time predictions of smolt outmigration dynamics for ESA-listed stocks and other runs-at-large for the Snake and Columbia Rivers. The fruit of this labor was the Program RealTime, a statistical software program which predicts run-timing of individual stocks of salmonids (Skalski et al. 1994). It uses historical data to predict the percentile of the outmigration that will reach an index site, in real-time; and it forecasts the elapsed time until some future percentile is observed at that site. The first in-season predictions were of wild spring/summer chinook salmon smolts from the Snake River drainage above Lower Granite Dam in their 1994 outmigrations. These fish originate in streams listed by the National Marine Fisheries Service (NMFS) as evolutionarily/ecologically significant units (ESUs). As parr, a portion of these fish are annually implanted with PIT (Passive Integrated Transponder, Prentice et al., 1990a, b, c) tags, and released back into their natal streams where they over-winter until their outmigration as yearlings in the spring and summer (Achord et al., 1994, 1995, 1996, 1997, 1998, 2000). During outmigration, PIT-tag detectors at Lower Granite Dam read the tag codes so individual stocks can be monitored.

University of Washington fisheries scientists subsequently incorporated Program RealTime predictions into their CRiSP model to move the forecasted runs of these stocks down the Snake and Columbia Rivers to Bonneville Dam (Hayes et al. 1996, Beer et al. 1999, *http://www.cqs.washington.edu/crisprt*).

Since 1994, the RealTime forecasting project has expanded its scope to track and forecast other NMFS-listed populations of Snake River salmonids. In 1997 program RealTime began forecasting the run-timing of a stock of hatchery-reared PIT-tagged summer-run sockeye salmon from Idaho's Redfish Lake (Townsend et al., 1998, Burgess et al. 1999); in 2000 a second stock of PIT-tagged hatchery sockeye salmon was included in the project, from Alturas Lake in Idaho.

The hatchery protocol of releasing unmarked smolts into the Snake River, begun in 1999 and continued in 2000, forced the discontinuance of RealTime forecasts of wild chinook salmon and steelhead trout runs-at-large to Lower Granite Dam because wild and hatchery fish became indistinguishable. These runs-at-large were previously tracked using FPC passage indices. In 1999, the RealTime project included a PIT-tagged subpopulation of the wild subyearling fall chinook salmon run. In 2000, additional PIT-tagged subpopulations, of wild yearling chinook salmon, and wild steelhead trout, were added to the RealTime project to salvage run-timing information about these wild runs-at-large.

In addition to Snake River stocks, the RealTime forecasting project included, for the first time in 2000, combined runs-at-large of wild and hatchery-reared subyearling and yearling chinook, coho and sockeye salmon, and steelhead trout outmigrating to Rock Island Dam on the mid-Columbia River and to McNary Dam on the mainstem of the Columbia River.

This report presents a post-season analysis of Program RealTime performance for 2000. Here we compare RealTime predictions with observed distributions of fish counts at Lower Granite, Rock Island, and McNary dams. During the outmigration season, predictions were interactively accessible daily, via the World Wide Web at address *http://www.cqs.washington.edu/crisprt.* The website's end-of-season graphical and tabular displays of Program RealTime results, by stock, are included in Appendices A and B of this report. Appendix A contains the daily record of RealTime predictions compared with the season-end observed distributions for all runs tracked by Program RealTime in 2000, and Appendix B contains historical run-timing information for each stock.

2.0 Methods

2.1 Description of Data

2.1.1 PIT-tag Data

PIT-tag data were made available by the Pacific States Marine Fisheries Commision's PIT Tag Information System (PITAGIS) project. In 2000 we tracked and prepared forecasts of outmigration timing to Lower Granite Dam for PIT-tagged wild Snake and Clearwater River yearling spring/summer chinook salmon, wild Snake River fall subyearling chinook salmon, wild Snake and Clearwater River steelhead trout, and hatchery-reared, summer-run sockeye salmon from Alturas and Redfish Lakes in Idaho. The wild yearling chinook salmon originated from nineteen streams or rivers above Lower Granite dam, where they were captured, PIT-tagged, and released as parr between May 31 and November 1, 1999. The wild subyearling chinook salmon were PIT-tagged and released into the Snake River near its confluence with the Salmon River, during April through July of 2000. Figure 1 shows the locations of the release sites for each of these chinook and sockeye salmon ESUs. Table 1 displays the U.S. Geological Survey hydrounit numbers for release sites. Aggregate populations of all wild PIT-tagged Snake River yearling chinook salmon and all wild PIT-tagged Snake River steelhead trout were tracked and their run-timing forecasted for the first time, in 2000.

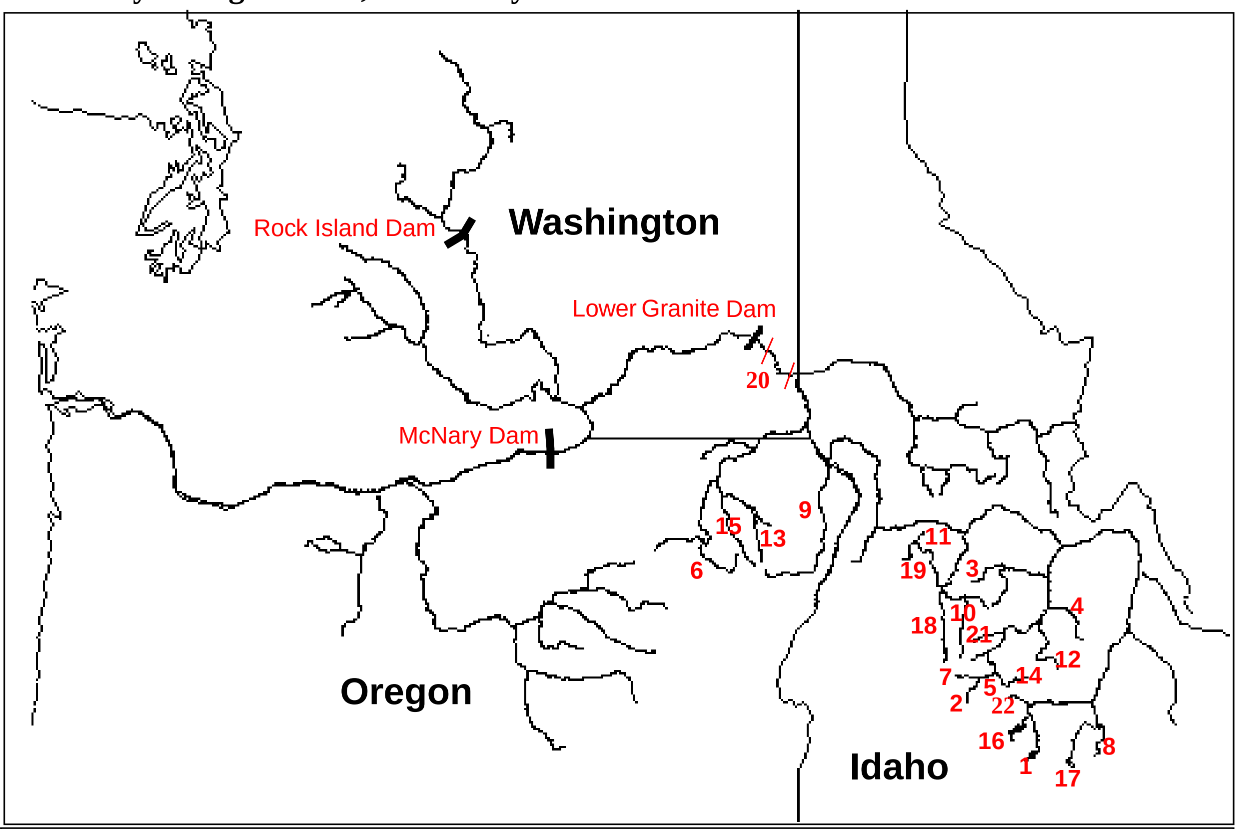
Spring/summer Yearling Chinook Salmon PIT-tag/Release Data

The RealTime 2000 project included nineteen stocks of smolts originating from tag/release sites (streams or rivers) above Lower Granite Dam. Each stock constitutes a unique ESU. Originally, tag/release sites were chosen on the basis of their consistent recovery numbers (PIT-detections at LGR)[1], and by virtue of having at least three years of historical data, each with at least 30 PIT-tag detections. Over the years, stocks with less historical information were also forecasted in order to determine whether a lower standard would still provide good predictions. In

1.Detections of PIT-tagged smolts at Lower Granite Dam can be seen as recaptures or recoveries in a mark-release experiment, so the terms "recapture", "recovery", and "detection" will be used interchangeably throughout this report.

addition, we forecast “composite runs” which are the combined data from several streams treated as a single stock. The composite runs produce good predictions because they smooth and dampen the randomness of individual stocks. They can be useful for providing general run-timing information for groupings of release sites. In 2000 there were three composites. The sites included in the CRiSP/RealTime composite had to meet the extreme data requirements of the CRiSP model. These sites included Catherine Creek, Imnaha River, Minam River, and South Fork Salmon River. The RealTime Select Composite consisted of sites that met the less stringent historical data requirements described above for program RealTime. In addition to the CRISP/RealTime

Figure 1: Map showing PIT-tag/release sites used in forecasting outmigration timing by Program RealTime in 2000, for spring/summer yearling chinook, fall sub-yearling chinook, and sockeye salmon ESUs.



Release Sites

1. Alturas Lake
2. Bear Valley Creek
3. Big Creek
4. Camas Creek
5. Cape Horn Creek
6. Catherine Creek
7. Elk Creek
8. Herd Creek
9. Imnaha River
10. Johnson Creek
11. Lake Creek
12. Loon Creek
13. Lostine River
14. Marsh Creek
15. Minam River
16. Redfish Lake
17. Salmon R., East Fork
18. Salmon R., South Fork
19. Secesh River
20. Snake River kilometer 224-268
21. Sulfur Creek
22. Valley Creek

Composite-stocks, these included Bear Valley Creek, Big Creek, Elk Creek, Lake Creek, Lostine River, Marsh Creek, Salmon River (East Fork) and Secesh River. The third composite was the RealTime All-Stocks composite which included all sites (Figure 1, Table 1).

Table 1: The GIS hydrounits of PIT-tag/release sites for chinook and sockeye salmon stocks included in the 2000 Program RealTime forecasting project.

Release Site		Rearing	Run	Species	GIS Hydrounit[a]
Abbreviation	Long Name				
ALTURL	Alturas Lake	H	Su	Sockeye	17060201
BEARVC	Bear Valley Creek	W	Sp/Su	Chinook	17060205
BIGC	Big Creek	W	Sp/Su	Chinook	17060206
CAMASC	Camas Creek	W	Sp/Su	Chinook	17060206
CAPEHC	Cape Horn Creek	W	Sp/Su	Chinook	17060205
CATHEC	Catherine Creek	W	Sp/Su	Chinook	17060104
ELKC	Elk Creek	W	Sp/Su	Chinook	17060205
HERDC	Herd Creek	W	Sp/Su	Chinook	17060201
IMNAHR	Imnaha River	W	Sp/Su	Chinook	17060102
JOHNSC	Johnson Creek	W	Sp/Su	Chinook	17060208
LAKEC	Lake Creek	W	Sp/Su	Chinook	17060208
LOONC	Loon Creek	W	Sp/Su	Chinook	17060205
LOSTIR	Lostine River	W	Sp/Su	Chinook	17060105
MARSHC	Marsh Creek	W	Sp/Su	Chinook	17060205
MINAMR	Minam River	W	Sp/Su	Chinook	17060106
REDFL	Redfish Lake	H	Su	Sockeye	17060201
SALREF	Salmon River, East Fork	W	Sp/Su	Chinook	17060201
SALRSF	Salmon River, South Fork	W	Sp/Su	Chinook	17060208
SECESR	Secesh River	W	Sp/Su	Chinook	17060208
SNAKER	Snake River (RK 224 to 268)	W	Fall	Chinook	17060110
SULFUC	Sulfur Creek	W	Sp/Su	Chinook	17060205
VALEYC	Valley Creek	W	Sp/Su	Chinook	17060201

a.Geographical Information System (GIS) designations established by the U.S. Geological Survey.

In order to ensure representative sampling of the wild yearling spring/summer stocks, it was established in 1998 that only Lower Granite PIT-detections of yearling chinook tagged and released by experienced taggers Paul Sankovitch and Steve Achord would be used by RealTime. Parr whose tags are implanted by inexperienced taggers or for other experimental reasons could bias the samples. Also, to maintain consistency between pre- and post-1993 PIT-tagging practices, (after 1993, tagging continued into late fall and winter, Ashe et al. 1995, Blenden et al. 1996, Keefe et al. 1995, 1996) we use only detections of fish tagged from May 31 through November 1 of the previous year. Fish marked during different seasons have shown differences in migrational timing to Lower Granite Dam (Keefe et al. 1995, 1996).

Snake River Fall Subyearling Chinook Salmon PIT-tag/release Data

Included in 2000 for the second consecutive year, the PIT-tagged subpopulation of all PIT-tagged wild fall subyearling chinook salmon is tracked to provide run-timing information about the wild run-at-large of Snake River fall subyearling chinook salmon. Passage indices for the wild run became unavailable after June 6, 1999 (Burgess, et al., 1999). Historical comparisons of the passage distributions of the run-at-large with the PIT-tagged subpopulation were available at the world-wide website *www.cbr.washington.edu/crisprt/info.html* for 1993-1998. From 1993-2000, William Connor (USFWS at Dworshak Fisheries Complex) sampled, PIT-tagged and released subyearling fall chinook in the Snake River between river kilometers 224 and 268 as part of his doctoral research. The smolts were tagged and released at regular intervals, from April into July or until water temperatures approached 20^{o}C or catches neared zero. The smolts were then tracked at Lower Granite dam from approximately June 1 through October of the same year. The subpopulation mimics the run-at-large passage percentiles well during the first and middle portions of the run.

Alturas and Redfish Lake Sockeye Salmon PIT-tag/Release Data

RealTime forecaster observations of Alturas and Redfish Lake sockeye PIT-tagged smolts at Lower Granite dam were restricted to fish tagged and released between July 31 and December 31 of the previous year, to ensure consistency of recoveries. Alturas Lake sockeye were tracked and forecasted in 2000 for the first time by program RealTime.

Snake River Steelhead Trout and Spring/Summer Chinook Salmon PIT-tag Count Data

In addition to the twenty-two tag/release ESUs of chinook and sockeye salmon, the RealTime forecasting project included two aggregates of PIT-tagged smolts treated as count data, not as tag/release data. The first, an aggregation of all wild spring/summer detected at Lower Granite Dam in 2000, was not an ESU because it included spring/summer chinook from the Clearwater River, which is not an ESU. The second, the aggregation of all wild PIT-tagged steelhead trout detected at Lower Granite Dam in 2000, did constitute an ESU. These aggregate stocks may provide run-timing information about the wild runs-at-large. Historical comparisons of the passage distributions of the runs-at-large with the PIT-tagged subpopulations were available at the world-wide website *www.cbr.washington.edu/crisprt/info.html*.

2.1.2 Passage Index Data

Passage index data were made available by the Northwest Power Planning Council's (NWPPC) Fish Passage Center (FPC). Passage indices are sample counts in the bypass system at the dam divided by the proportion of water passing through the sampling system. They are collected according to FPC sampling plans (Fish Passage Center, 1999), and reflect the size of the run.

Runs-at-large of combined wild and hatchery salmonids migrating to Rock Island Dam and Mcnary Dam

Run-timing characteristics of mid-Columbia and mainstem Columbia River migrant stocks were predicted by Program RealTime for the first time in 2000. We used FPC passage indices of combined wild and hatchery spring/summer yearling and fall subyearling chinook, and coho and sockeye salmon, and steelhead trout to track and forecast these runs to Rock Island Dam on the mid-Columbia River and to McNary Dam on the mainstem Columbia River. Large hatchery releases into the rivers can disturb the pattern of normal fish passage, making predictions difficult.

2.2 Preprocessing

Raw PIT-tag count data are adjusted for spill fraction (Section 2.3) and smoothed using three 5-day smoothing passes to filter out statistical randomness, before input to the RealTime forecaster algorithm. Raw passage index data are smoothed the same as PIT-data. Passage indices are flow-adjusted by the FPC (Section 2.1.2).

2.3 Adjustment of Raw PIT-tagged Smolt Counts.

Because some PIT-tagged smolts pass Lower Granite Dam undetected by the dam's PIT-tag detection system, for example through the spillway, the daily number of fish observed, "raw smolt counts" are multiplied by an expansion factor, resulting in "adjusted counts" according to the formula

raw counts x expansion factor = adjusted counts.

It is the adjusted counts which program RealTime uses in forecasting run-timing. In 2000, as in 1999, the expansion factor was

$$\frac{1}{1 - SE},$$

where SE is *spill effectiveness*, the fraction of smolts passing through the spillway (NMFS, 2000). Different species of salmonids use hydroelectric passage routes differently (Skalski and Perez-Comas, 1998) and a different formula was used for steelhead trout spill effectiveness than the one used for chinook and sockeye salmon. The formula for spill effectiveness for chinook and sockeye salmon is given by Smith et al. (1993) as

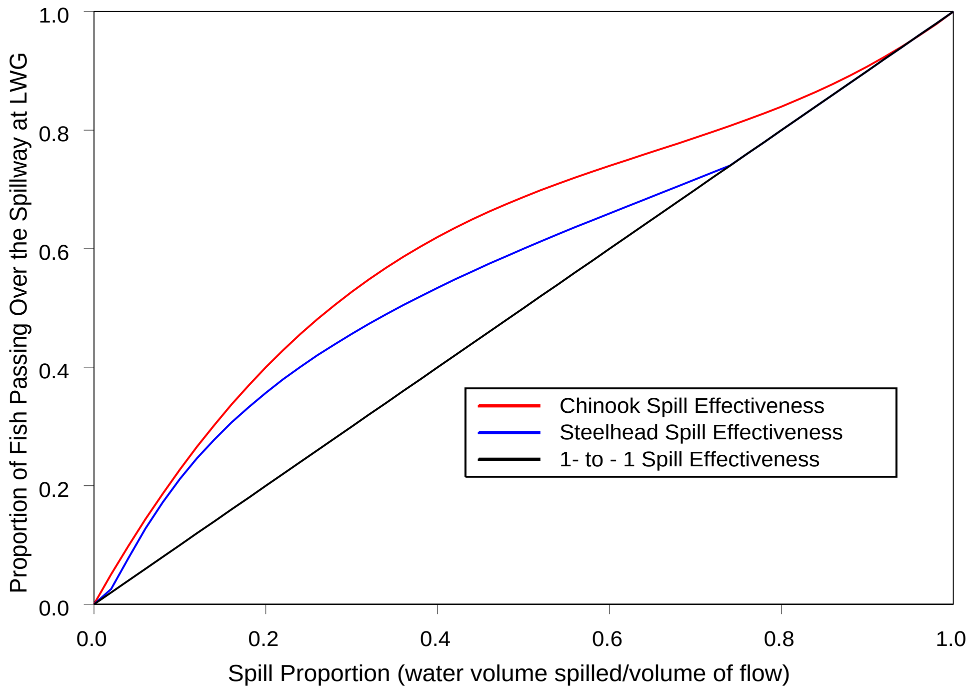
$$SE_{chinook,sockeye} = 1.667\left(\frac{S}{F}\right)^3 - 3.25\left(\frac{S}{F}\right)^2 + 2.583\left(\frac{S}{F}\right) \qquad (1)$$

(Figure 2, red), and the formula for steelhead is given by Skalski and Perez-Comas (1998) as

$$SE_{steelhead} = 0.6001 \tag{2}$$

(Figure 2, blue), where S is the daily volume of water spilled and F is daily outflow volume (Figure 2).

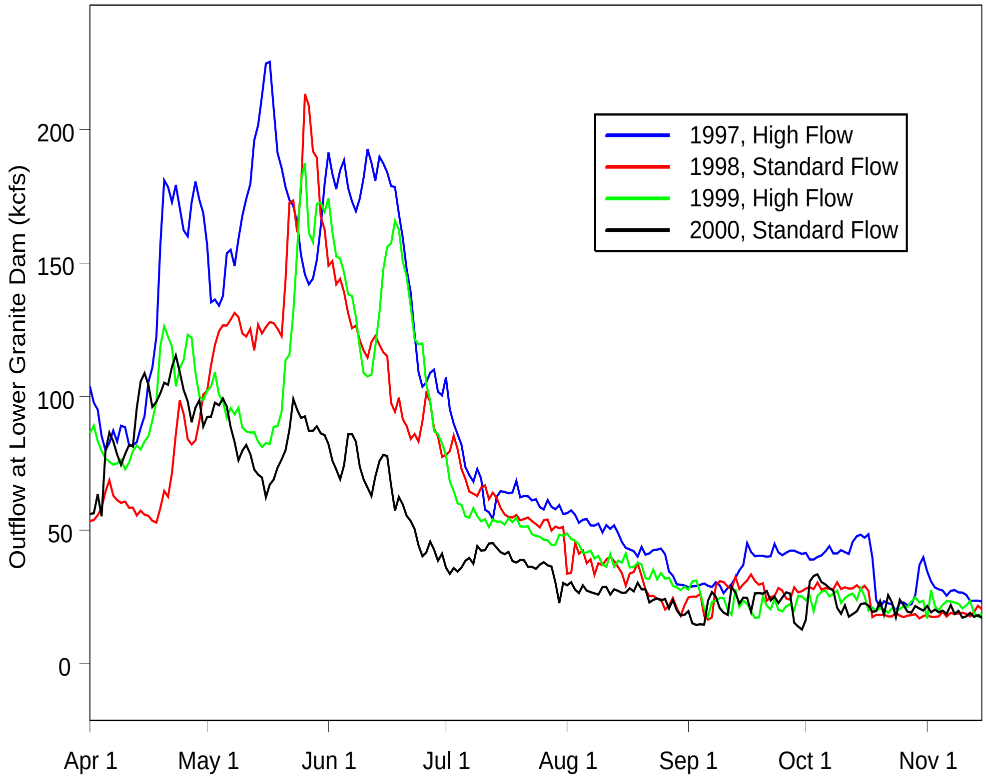
Figure 2. Spill effectiveness (SE) function (equations 1 and 2) used by Program RealTime to upwardly adjust raw PIT-tag detections. Shown are the 2000 RealTime spill effectiveness curves as functions of spill proportion (S/F) compared with a 1-to-1 function.



2.4 Outflow at Lower Granite Dam

Although it has not been conclusively demonstrated, flow (which is highly correlated with a number of other river variables, such as turbidity and temperature) is thought to substantially affect wild fall subyearling chinook salmon outmigration timing (Connor, et al. 1994b and 1996; Giorgi and Schlechte 1997; Smith et al.1997). Flow surges may influence the numbers of fry that migrate from upriver spawning grounds (Healey, 1991). The 2000 flow year was considered a standard flow year like 1998 (Figure 3), relative to high flow years such as 1997 and 1999.

Figure 3. Outflow volumes at Lower Granite Dam, April 1-November1, for 1997, 1998, 1999, and 2000. Migration year 2000 showed lower-than-average flow.



2.5 Migration Year 2000.

The hatchery practice of releasing unmarked fish into the Snake River, first implemented in 1999 for subyearling fall chinook salmon, was extended to include yearling chinook salmon and steelhead trout in 2000. The result is that no wild runs-at-large are currently tracked at Lower Granite Dam, using passage indices. The release in of large numbers of unmarked hatchery smolts into the Snake River has made it impossible for the Fish Passage Center to distinguish between wild and hatchery fish. It is fundamental to the RealTime forecasting process to distinguish the wild from hatchery stocks on the Snake River because large, highly variable releases of hatchery fish obliterate the signature patterns of wild fish passage. We continue to provide information about these wild runs to Lower Granite Dam by tracking PIT-tagged subpopulations of the runs (Section 2.1.1).

2.6 Models

2.6.1 The RealTime Forecasting Algorithm

The RealTime forecaster is essentially a pattern-matching algorithm. However, at the beginning of the outmigration there is very little in the way of a pattern to match. To optimize predictions for all phases of the outmigration, the forecaster utilizes three models: a start-up model for initial predictions, the pattern-matching model, and a switching model to govern the timing of the switch between the start-up and pattern-matching models.

The pattern-matching portion is accomplished by a least-squares (LS) model, where the patterns are cumulative percentage curves of outmigrating smolts. Current-year data are compared with historical cumulative percentage curves by comparing their slopes at each percentile, $j = 1, \ldots, 100$, using the measure

$$\sum_{j} (s_j - s_{ijp})^2 , \tag{3}$$

where s_j is the slope at the j^{th} percentile of current-year data to-date and s_{ijp} is slope at the j^{th} percentile of p percent of historical year i 's outmigration. The value of p that minimizes (3), i.e.,

$$\min_{p} \left[\sum_{j=1} (s_j - s_{ijp})^2\right], \qquad p = 0, \ldots, 100 \tag{4}$$

is the best predictor from the point of view of pattern-matching to historical year i.

The start-up model produces run-percentage (RP) estimates

$$\frac{x_d}{E(\hat{S})}, \tag{5}$$

where x_d is the total number of fish observed by day d of the outmigration, and $E(\hat{S})$ estimates the total expected outmigration to Lower Granite dam. The expectation is estimated differently, depending on the type of data. For the PIT-tagged stocks for which there is reliable annual release/recapture data (i.e., the nineteen spring/summer yearling chinook salmon stocks, the two sockeye salmon stocks, and the subyearling chinook salmon stock) $E(\hat{S})$ is equal to $\bar{r}\ x\ N$, where $\bar{r}$ is the average historical recapture percentage (detections divided by "releases", the number of PIT-tagged fish released at a particular site per year) at Lower Granite dam, and N is total releases the previous year for PIT-tagged stocks. Tables 2 and 3 display the information used by program Realtime to compute these estimates. For passage index data and aggregate PIT-populations (the yearling chinook salmon and steelhead trout stocks), which are simply count data, not appropriate for release-recapture treatment, $E(\hat{S})$ is the average historical run size. Table 4 displays information for yearling chinook salmon and steelhead trout populations. Tables 5 and 6 display information for the combined wild and hatchery run-at-large of mid-Columbia and Columbia salmonids outmigrating to Rock Island and McNary Dams.

The RP estimates, (5), are more accurate than LS (pattern-matching) estimates (4) initially, but are quickly outperformed by LS estimates as the season progresses (Townsend et al., 1995, 1996, 1997).

The switching model is an age-of-run (AR) model based on mean fish run age (MFRA). Thus each model provides a unique own estimate of the true passage percentile. The algorithm selects the best $p = 0, \ldots, 100$ by combining the three (LS, RP, and AR) model estimates, their estimated errors, and two additional switching parameters into a nonlinear combination. The estimated error for the LS model was given in (3) above, and the estimated errors for the RP and AR models are, respectively,

$$\left| \log p - \log \hat{RP} \right|, \quad p = 0, \ldots, 100 \tag{6}$$

and

$$\left| \log p - \log \hat{AR} \right|, \quad p = 0, \ldots, 100, \tag{7}$$

where $\hat{RP}$ in (6) is the RP model estimator (5) and $\hat{AR}$ in (7) is the AR model estimate, based on MFRA. For a complete description of the algorithm's mathematical details, see Burgess, et al., 1999. By including age-of-run (AR) and run percentage (RP) information, the forecaster effectively combines these indicators together with the least-squares (LS) pattern-matching model into a single, more accurate and robust predictor.

Table 2: Data used by program RealTime in 2000 to compute initial predictions (formula 5), for PIT-tagged stocks of wild Snake River spring/summer yearling chinook salmon and hatchery-reared sockeye salmon. Column (1) is the number, N, of PIT-tagged parr released in 1999, by site. Columns (2) and (3) are the raw and adjusted numbers, respectively, of PIT-tagged smolts detected at Lower Granite Dam in migration year 2000. Columns (4) and (5) show historical recapture percentages and number of years of historical data, respectively, for each site. Column (6) shows the 2000 recapture percentages (col.3/col.1).

Tagging Location	(1) 1999 Parr Pit-tagged	(2) 2000 Raw PIT Detections	(3) 2000 Adjusted PIT Detections	(4) Number Years of Historical Data	(5) Average Historical Recapture Percentages, $\bar{r}$	(6) 2000 Recapture Percentages[a] (col.3/col.1)
Alturas Lake	1554	117	222.3	2	25.5	14.3
Bear Valley Creek	837	44	85.1	8	11.7	10.2
Big Creek	1090	92	177.2	7	10.6	16.3
Camas Creek	763	53	103.7	3	10.3	13.6
Cape Horn Creek	423	17	32.9	5	12.6	7.8
Catherine Creek	499	30	57.2	9	13	11.5
Elk Creek	660	42	80.3	7	14.9	12.2
Herd Creek	315	23	44.3	4	9.1	14.1
Imnaha River	982	63	119.5	11	12.2	12.2
Johnson Creek	913	49	94.5	2	12.5	10.3
Lake Creek	603	30	54.5	7	10.6	9.0
Loon Creek	719	47	90.0	4	13.9	12.5
Lostine River	509	36	68.8	8	13	13.5
Marsh Creek	554	23	46.6	7	10.8	8.4
Minam River	998	74	142.1	7	14.3	14.2
Redfish Lake	1557	42	80.5	5	4.7	5.2
Salmon River, East Fork	674	35	66.2	6	6.1	9.8
Salmon River, South Fork	1010	39	72.0	10	9.5	7.1
Secesh River	907	40	74.2	11	10.9	8.2
Sulfur Creek	838	52	99.0	5	8.9	11.8
Valley Creek	1009	51	95.7	8	5.2	9.5

a.Data Sources: PTAGIS Database and RealTime program output as of 9 November 2000.

Table 3: Data used by program RealTime in 2000 to compute initial predictions, (formula 5 in text), for wild Snake River fall subyearling chinook salmon. Column (1) is the number, N, of PIT-tagged smolts released in April through July of 2000 near the confluence of the Snake and Salmon Rivers. Columns (2) and (3) show the raw and adjusted numbers, respectively, of PIT-detections at Lower Granite Dam for 2000. Columns (4) and (5) show the historical recapture percentages and the number of years of historical data, respectively, and column (6) shows the 2000 recapture percentage (col.3/col.1).

Tagging Location	(1) Apr-Jul Smolts Pit-tagged, N	(2) Jun-Nov, Raw PIT Detections	(3) Jun-Nov Adjusted PIT Detections	(4) Years of Historical Data	(5) Average Historical Recapture Percentage, $\bar{r}$	(6) 2000 Recapture Percentage[a]
Snake River, river km 224-268	1209	327	376.0	7	29.1	31.1

a.Data Sources: PTAGIS Database and RealTime program output as of 30 November 2000.

Table 4: Data used by program RealTime in 2000 to compute initial predictions, (formula 5 in text) for spill-adjusted PIT-tagged smolt counts of wild Snake River spring/summer yearling chinook salmon and steelhead trout.

Year	Spring/Summer Yearling Chinook Salmon	Steelhead Trout[a]
1991	---	2914
1992	---	3638
1993	3939	4757
1994	6889	5346
1995	9437	4458
1996	5418	3966
1997	2497	4459
1998	13425	8522
1999	17945	6988
2000	14541	13593

a.Data Sources: PTAGIS Database and RealTime program output as of 9 November 2000.

Table 5: Data used by program RealTime to compute initial predictions (formula 5 in text), for FPC passage indices of the runs-at-large of combined wild and hatchery steelhead trout and yearling and subyearling chinook and coho and sockeye salmon at Rock Island Dam. The passage indices reflect total run size.

Year	Steelhead Trout	Yearling Chinook Salmon	Subyearling Chinook Salmon	Coho Salmon	Sockeye Salmon[a]
1990	3739	---	---	---	---
1991	4953	---	---	---	---
1992	4906	16100	10339	---	---
1993	4032	13514	---	---	---
1994	15323	12324	---	---	---
1995	18084	30753	14149	---	27056
1996	39650	42478	15294	26521	9995
1997	33979	53754	19246	4301	13426
1998	21390	24859	17218	41837	16635
1999	48192	40320	28340	46173	23371
2000	26432	32359	15086	49568	2452

a.Data Sources: FPC Smolt Index Database and RealTime program output as of 5 December 2000.

Table 6: Data used by program RealTime to compute initial predictions (formula 5 in text), for FPC passage indices of the runs-at-large of combined wild and hatchery steelhead trout and yearling and subyearling chinook and coho and sockeye salmon at McNary Dam. The passage indices reflect total run size.

Year	Steelhead Trout	Yearling Chinook Salmon	Subyearling Chinook Salmon	Coho Salmon	Sockeye Salmon[a]
1992	---	2514319	6179484	---	---
1993	---	1729010	4283813	---	---
1994	106520	2572338	5053511	---	---
1995	734878	2879069	8223192	236480	1003494
1996	792462	1240878	6072944	647586	155094
1997	1234024	1184530	10383928	339949	221166
1998	571119	1727071	11440908	241239	966549
1999	1004348	3692944	7645173	281977	1446326
2000	617454	1986380	10614674	260048	139434

a.Data Sources: FPC Smolt Index Database and RealTime program output as of 5 December 2000.

2.6.2 Precision of Estimator: Confidence Intervals for $\hat{P}$

Each day of the run, a jackknife confidence interval is constructed for the daily prediction estimate, $\hat{P}$ (Section 2.6.1). Jackknifing is a computer-intensive method of extracting sampling distribution information about an estimator by recomputing the estimator from different subsets of the historical data. A jackknife subset consists of the complete set of historical years minus one year. If a release site has, say, six years of historical data, there will be 6 subsets of 5 years each. A prediction is estimated from each subset, and these jackknife predictions provide a measure of dispersion on which the daily confidence interval is based.

2.6.3 Evaluating RealTime Performance

The true outmigration percentile on day d (i.e., P_d) can only be observed after the run is finished (i.e. $P_{last} = 100\%$). When the run is over, we evaluate RealTime's performance using the mean of the absolute differences (MADs) between observed outmigration percentiles, P_d, and their estimates, $\hat{P}_d$, for all days, d:

$$MAD = \frac{\sum_{d=1}^{n} \left|\hat{P}_d - P_d\right|}{n}$$

where n is the total number of days in the outmigration run for the season.

3.0 Results

3.1 Wild PIT-tagged Spring/Summer Yearling Chinook Salmon ESUs

Table 7 shows the mean absolute deviations (MADs) of RealTime predictions for 2000, and comparisons to 1999 MADS where applicable. The daily absolute differences are averaged over the entire run, and separately over the first and last halves of the season.

In general, the performance of Program RealTime was quite good for the spring/summer chinook salmon ESUs, as can be seen from the daily prediction records (Appendix A) and the MADs (Table 7). Realtime 2000 performance improved over 1999 performance in several overall measures (it should be noted that 1999 performance itself was an improvement over previous years). The RealTime Select composite-run predictions (Figure 4) were, on average, within 2% (MAD=1.1%) of the true passage percentile for the whole-season run. They were within 1% (MAD=0.8%) over the first half of the run, and within 2% over the last half of the run (MAD=1.2%). The Select composite consists of those sites (in bold) meeting the original RealTime historical data requirements (Section 2.2.1).

Whole-season MADs for individual stocks in 2000 showed improved season-wide performance relative to previous years. Out of 16 release sites for which comparisons were available, 13 sites showed equal or improved performance relative to 1999, and the full-season mean MAD (MADs averaged over all sites) improved from 5.7% in 1999 to 4.5% in 2000. First-half performance in 2000 deteriorated slightly, on average, compared to 1999, with average first-half MAD up from 4.5% in 1999 to 5.1% in 2000. Last-half performance improved, down from 6.5% in 1999 to 4.3% in 2000, on average, over all sites. Poorest performances occurred primarily during the first half of the 2000 outmigration.

Table 7: Mean absolute deviations (MADs, section 2.6.3) for the 1999 and 2000 outmigrations to Lower Granite Dam of 19 wild PIT-tagged Snake River spring/summer yearling chinook salmon ESUs and three composite runs (section 2.1.1). Columns show MADs for the entire run, the first 50% of the run, and the last 50% of the run. Sites in bold are RealTime Select Composite release sites (section 2.1.1).

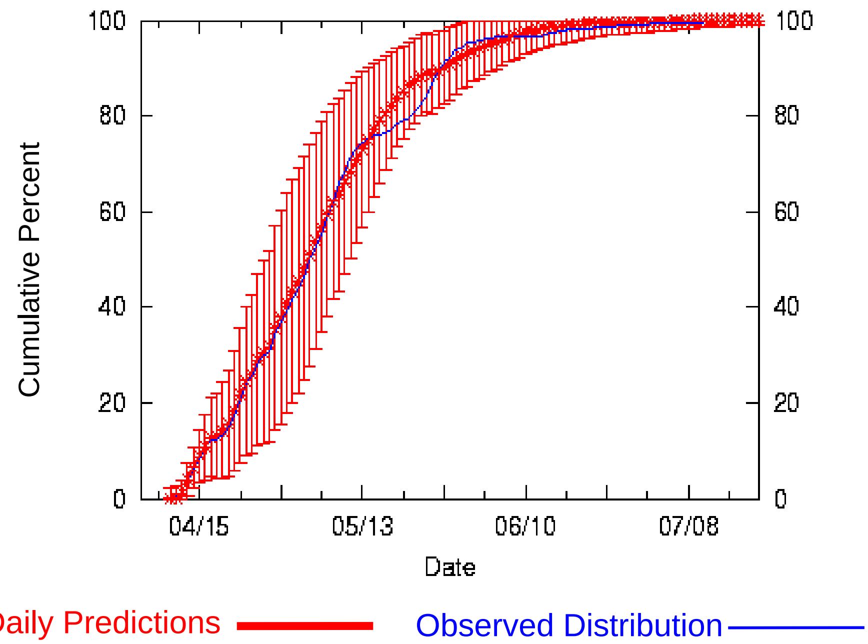
	1999			2000		
Tagging Site	Entire Run, %	First 50%, %	Last 50%, %	Entire Run, %	First 50%, %	Last 50%, %
Bear Valley Creek	**8.1**	**1.4**	**9.6**	**3.3**	**1.4**	**3.8**
Big Creek	**2.8**	**3.7**	**2.3**	**5.4**	**9.9**	**3.7**
Camas Creek	---	---	---	8.4	6.6	9.2
Cape Horn Creek	8.3	8.4	8.3	6.5	6.1	6.6
Catherine Creek	**6.2**	**4.0**	**7.7**	**5.2**	**0.8**	**7.6**
Elk Creek	**3.6**	**0.4**	**4.8**	**4.3**	**2.6**	**4.8**
Herd Creek	5.1	5.5	4.7	5.8	12.0	4.0
Imnaha River	**3.4**	**3.9**	**3.2**	**2.6**	**3.3**	**2.4**
Johnson Creek	---	---	---	4.8	1.8	6.4
Lake Creek	**3.2**	**1.7**	**3.6**	**3.2**	**3.2**	**3.3**
Loon Creek	8.8	12.9	6.6	1.7	0.9	2.2
Lostine River	**5.8**	**4.4**	**8.1**	**2.1**	**0.9**	**2.8**
Marsh Creek	**4.0**	**6.8**	**3.0**	**2.8**	**2.1**	**3.0**
Minam River	**5.8**	**2.8**	**7.8**	**2.2**	**2.8**	**1.9**
Salmon River, East Fork	**---**	**---**	**---**	**10.1**	**14.6**	**7.4**
Salmon River, South Fork	**5.9**	**0.9**	**10.2**	**2.9**	**1.5**	**3.4**
Secesh River	**3.9**	**1.2**	**4.9**	**3.5**	**5.2**	**3.3**
Sulfur Creek	9.1	6.6	11.9	4.9	8.1	2.9
Valley Creek	7.4	7.5	7.4	5.5	12.9	2.9
mean MAD[a]	5.7	4.5	6.5	4.5	5.1	4.3
median MAD[a]	5.9	4.2	7.0	4.3	3.2	3.4
range[a]	2.8 - 9.1	0.4 - 12.9	2.3 - 11.9	1.7 - 10.1	0.8 - 14.6	1.9 - 9.2
mean MAD of RealTime Select composite sites[b]	**4.8**	**2.8**	**5.9**	**4.0**	**4.0**	**4.0**
Select Composite Run[c]	**1.9**	**1.0**	**2.3**	**1.1**	**0.8**	**1.2**
CRiSP/RealTime Composite Run	**2.5**	**2.7**	**2.5**	**1.7**	**1.4**	**1.7**

a. These statistics are based on all release sites for the given year.

b. These statistics based on RealTime Select Composite sites only: Bear Valley Creek, Big Creek, Catherine Creek, Elk Creek, Imnaha River, Lake Creek, Lostine River, Minam River, and South Fork Salmon River, Secesh River for both years.

c. Combined data from RealTime Select composite sites, processed by Program RealTime as a single population.

Figure 4: RealTime Select Composite (Section 2.1.1) daily predictions with jackknifed confidence intervals (red) compared to the observed run (blue).



The RealTime CRiSP composite predicted even more accurately than 1999's exceptional predictions, with the whole-season MAD down from 2.7% in 1999 to 1.7% in 2000; the last-half MAD for this composite decreasing from 2.5% in 1999 to 1.7% in 2000, and the first-half MAD decreased from 2.7% to 1.4% in 2000. Sites belonging to the RealTime CRiSP composite, being comparatively data-rich, are generally better performers than other sites. This year all four of the CRiSP/RealTime sites improved in performance for the season-wide run, relative to 1999.

Eight sites showed exceptional first-half performance, with predictions falling within 3% of observed percentiles, on average season-wide (Bear Valley Creek, Catherine Creek, Elk Creek, Johnson Creek, Loon Creek, Lostine River, Marsh Creek, Minam River, and South Fork Salmon River). The largest first-half MAD was for the East Fork of the Salmon River, a new stock this year. Last-half performance improved in 2000, compared to 1999. Out of sixteen sites available for comparison with 1999 RealTime performances, fifteen showed improved predictions in 2000.

Figure 5 and Table 8 show run-timing characteristics for each stock during the 2000 outmigration. Figure 5 shows the distance of the release sites above Lower Granite Dam, in river kilometers. The middle 80% of the RealTime Select Composite run (time period between dashed lines) contains the 50th percentile of smolt passage (red dots) for all the yearling chinook release sites. A lagging of migration timing for longer migration distance is somewhat apparent this year. Appendix B contains detailed historical outmigration information for each of the 19 release sites tracked in 2000.

Table 8: End-of-season 2000 passage dates at Lower Granite Dam (for first and last observations, and 10th, 50th, and 90th percentiles) of 19 wild PIT-tagged Snake River spring/summer yearling chinook salmon ESUs and their composite runs (section 2.1.1).

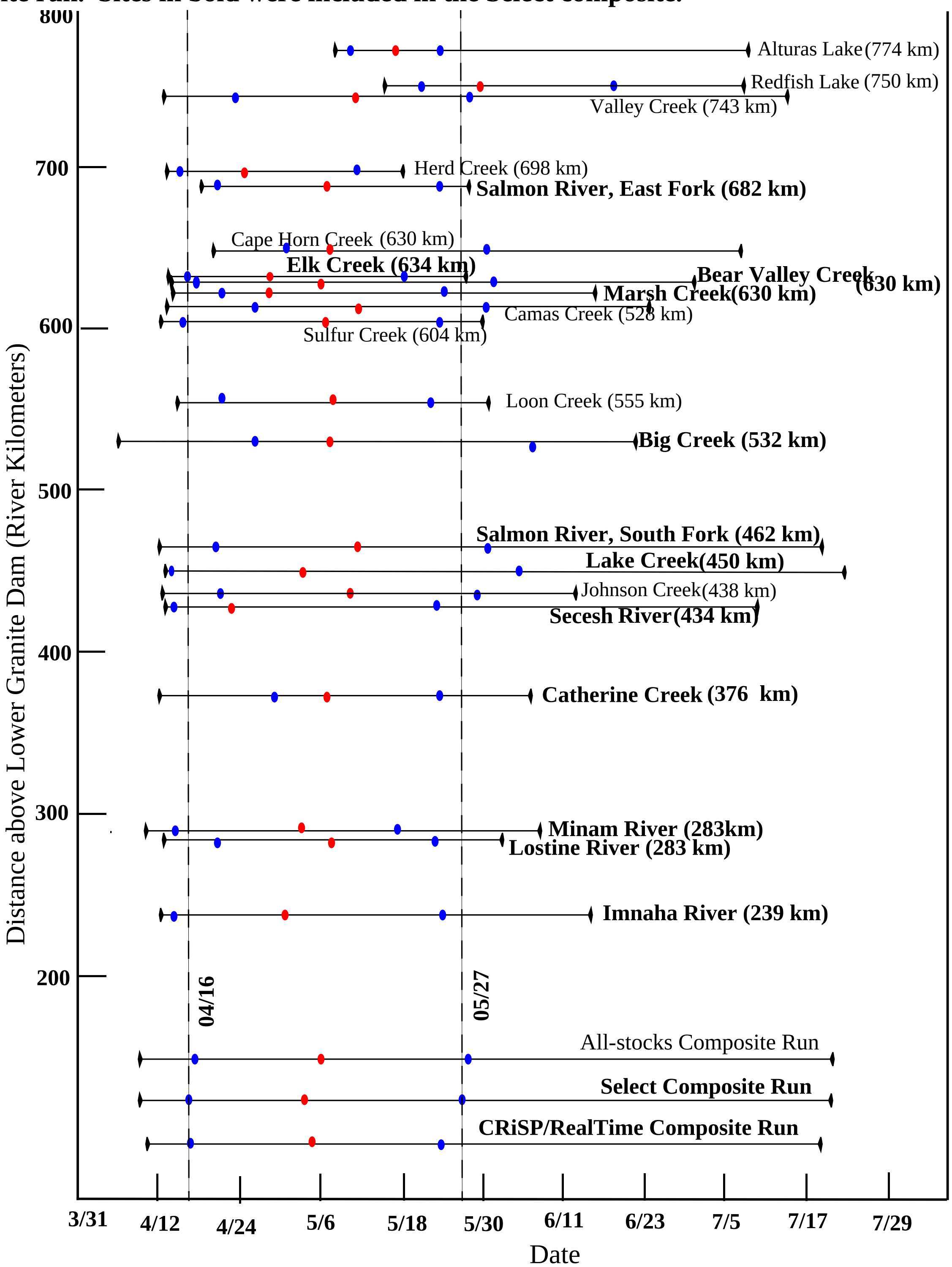
Population or Stock	Passage Dates at Lower Granite Dam			
	10%	50%	90%	Range (First - Last)
Bear Valley Creek	04/18	05/06	06/02	04/14 - 07/02
Big Creek	04/22	05/09	05/30	04/15 - 06/29
Camas Creek	04/26	05/12	06/01	04/13 - 06/24
Cape Horn Creek	05/01	05/08	06/01	04/20 - 07/09
Catherine Creek	04/30	05/07	05/23	04/12 - 06/07
Elk Creek	04/16	04/28	05/19	04/13 - 05/28
Herd Creek	04/16	04/25	05/11	04/14 - 05/19
Imnaha River	04/14	05/02	05/24	04/12 - 06/16
Johnson Creek	04/21	05/09	05/29	04/12 - 06/13
Lake Creek	04/13	05/03	06/05	04/13 - 07/24
Loon Creek	04/22	05/08	05/23	04/14 - 06/01
Lostine River	04/22	05/08	05/25	04/13 - 06/03
Marsh Creek	04/21	04/28	05/25	04/14 - 06/16
Minam River	04/15	05/03	05/17	04/10 - 05/29
Salmon River, East Fork	04/21	05/07	05/25	04/15 - 05/27
Salmon River, South Fork	04/20	05/11	05/31	04/12 - 07/20
Secesh River	04/13	04/23	05/23	04/12 - 07/11
Sulfur Creek	04/16	05/07	05/23	04/12 - 05/30
Valley Creek	04/23	05/11	05/28	04/13 - 07/14
CRiSP RealTime Composite[a]	04/16	05/05	05/25	04/10 - 07/20
Select Composite[b]	04/16	05/04	05/27	04/10 - 07/21
All-stocks composite[c]	04/17	05/06	05/28	04/10 - 07/21

a. The RealTime Composite includes the release sites Catherine Creek, Imnaha, Minam and South Fork Salmon Rivers, those streams that met CRiSP RealTime historical criteria defined in the text.

b. The Select Composite includes the release sites Bear Valley Creek, Big Creek, Catherine Creek, Elk Creek, Imnaha River, Lake Creek, Lostine River, Marsh Creek, Minam River, South Fork, Salmon River, and Secesh River.

c.The All-stocks Composite combines data from all 16 release sites.

Figure 5. Run-timing plots of 2000 passage dates (10%, 90%, blue dots; 50%, red dot; and range, endpoints), at Lower Granite Dam for wild Snake River spring/summer yearling chinook salmon ESUs and composites (section 2.1.1), and the Alturas and Redfish Lake sockeye salmon ESUs. Vertical axis gives distance in river kilometers of release sites to Lower Granite Dam. Dashed lines show dates of 10% and 90% passage for the RealTime Select composite run. Sites in bold were included in the Select composite.



3.2 Hatchery-reared Sockeye Salmon ESUs

Alturas and Redfish Lake sockeye salmon are summer-run fish that are hatchery-reared. The 2000 RealTime performance was the best on record for Redfish Lake, though the high variability in historical data for this stock still produced extremely large confidence intervals in 2000, as in previous years (Figure A11, Appendix A). First-half performance of Program RealTime predictions of this stock improved from a MAD of 6.9% in 1999 to 3.9% in 2000 (Table 9). Last-half and whole-season performances were also slightly improved over last year with whole-season MAD down from 6.7% in 1999 to 6.0% in 2000. Alturas Lake smolt passage, with only 2 years of historical data, was predicted well, with whole-season MAD equal to 4.3%. The first-half MAD was 11.6%. Run-timing information is displayed in Table 10 and in Tables B21 and B22, Appendix B. With only three years of data for Alturas Lake, norms are difficult to establish. The outmigration appeared to extend late into the summer in 2000, and the detection rate was smaller than in previous years for this stock. Run-timing characteristics and detection rate were near the historical averages for Redfish Lake, which may explain its best prediction record for 2000.

Table 9: Mean absolute deviations (MADs, section 2.6.3) for the 1999 and 2000 outmigrations to Lower Granite Dam of the PIT-tagged hatchery-reared Alturas and Redfish Lake sockeye salmon ESUs. Columns show MADs for the entire run, the first 50% of the run, and the last 50% of the run.

	1999			2000		
Run	Entire Run	First 50%	Last 50%	Entire Run	First 50%	Last 50%
Alturas Lake Sockeye	---	---	---	4.3	11.6	3.3
Redfish Lake Sockeye	6.7	6.9	6.7	6.0	3.9	6.5

Table 10: End-of-season 2000 passage dates at Lower Granite Dam (for first and last observations, and 10th, 50th, and 90th percentiles) of PIT-tagged sockeye and chinook salmon, and steelhead trout stocks tracked and forecasted by Program RealTime.

Population or Stock	Passage Dates at Lower Granite Dam			
	10%	50%	90%	Range (First - Last)
Hatchery Sockeye Salmon (Alturas Lake, ESU)	05/10	05/17	05/25	05/08 - 07/09
Hatchery Sockeye Salmon (Redfish Lake, ESU)	05/21	05/29	06/19	05/15 - 07/08
Wild Subyearling.Chinook Salmon (SNAKER, ESU)	06/16	07/01	08/04	05/06 - 10/28
All Wild Yearling Chinook Salmon	04/14	05/01	06/01	04/02 - 09/14
All Wild Steelhead Trout (ESU)	04/15	05/02	05/22	03/26 - 08/03

3.3 PIT-tagged Subpopulations of Wild Snake River Runs-at-Large

3.3.1 Wild PIT-tagged Fall Subyearling Chinook Salmon ESU

The MAD for the last half of the outmigration of this PIT-tagged subpopulation of the wild fall subyearling Snake River run-at-large was 5.5% in 2000 compared to 3.6% in 1999, a slight increase over last year (Table 11). First-half performance improved, decreasing from 9.5% in 1999 to 3.2% in 2000. The season-wide MAD increased slightly from last year, up from 4.7% in 1999 to 4.9% in 2000.

Run-timing characteristics and detection rates were unremarkable (Table B23, Appendix B).

Table 11: Mean absolute deviations (MADs) for the 2000 outmigration to Lower Granite Dam, of the PIT-tagged subpopulation of the wild Snake River fall subyearling chinook salmon run-at-large. Columns show MADs for the entire run, the first 50% of the run, and the last 50% of the run.

	1999			2000		
Stock	Entire Run	First 50%	Last 50%	Entire Run	First 50%	Last 50%
Wild PIT-tagged Fall Subyearling Chinook Salmon released between river kilometers 224 and 268 (SNAKER)	4.70	9.46	3.62	4.9	3.2	5.5
All Wild PIT-tagged Spring/Summer Yearling Chinook Salmon Detected at LWG during MY2000	---	---	---	1.7	5.0	1.0
All Wild PIT-tagged Steelhead Trout Detected at LWG during MY2000	---	---	---	4.8	10.8	2.8

3.3.2 Wild PIT-tagged Spring/Summer Yearling Chinook Salmon Stock

RealTime performance for this stock was exceptionally good, with whole season MAD equal to 1.7%, first-half MAD equal to 5.0 and last-half MAD, 1.0 (Table 11). The total number of PIT-tagged spring/summer yearling chinook detected in 2000 was above the historical average but within the normal range (Table 4).

3.3.3 Wild PIT-tagged Steelhead Trout ESU

Performance for this stock overall was very good, with the last half MAD equal to 2.8% (Table 11). The large first-half MAD of 10.8% was probably due to the extremely large number of PIT-tagged steelhead trout detected at Lower Granite Dam in 2000 (N=13,593, Table 4), compared to the historical average of 5006 annual detections. When number of smolts is much larger than expected, initial prediction tend to be high relative to the observed distribution, a phenomenon observed in 1998 when PIT-detection rates and passage indices were uncharacteristically large, resulting in over-prediction during the first half of the outmigrations (Burgess et al., 1999).

3.4 Combined Wild and Hatchery Columbia and Mid-Columbia Runs-at-Large

The runs-at-large of combined wild and hatchery-reared yearling and subyearling chinook salmon, coho salmon, sockeye salmon, and steelhead trout to Rock Island Dam on the Mid-Columbia River and to McNary Dam on the Columbia River (Figures A14-A18, Appendix A) were included in the RealTime forecasting project for the first time in 2000. The MADs for these runs in 2000 are shown in tables 12 and 13. While some runs showed exceptional predictive accuracy and precision (coho salmon migrating to both dams, yearling chinook at McNary Dam)

Table 12: Mean absolute deviances (MADs, section 2.6.3) for the 2000 outmigrations to Rock Island Dam of FPC passage indices of the combined wild and hatchery Mid-Columbia River steelhead trout and chinook, coho and sockeye salmon runs-at-large. Columns show MADs for the entire run, the first 50% of the run, and the last 50% of the run.

	2000		
Run-of-Year	Entire Run	First 50%	Last 50%
Subyearling Chinook Salmon	2.90	3.97	1.94
Yearling Chinook Salmon	5.04	15.70	1.76
Coho Salmon	1.04	1.77	0.50
Sockeye Salmon	16.96	19.45	16.23
Wild Steelhead Trout	4.47	10.83	2.07

Table 13: Mean absolute deviances (MADs, section 2.6.3) for the 2000 outmigrations to McNary Dam of FPC passage indices of the combined wild and hatchery Mid-Columbia River steelhead trout and chinook, coho and sockeye salmon runs-at-large. Columns show MADs for the entire run, the first 50% of the run, and the last 50% of the run.

Run-of-Year	2000		
	Entire Run	First 50%	Last 50%
Subyearling Chinook Salmon	1.57	3.43	1.25
Yearling Chinook Salmon	0.59	0.71	0.55
Coho Salmon	0.72	0.88	0.66
Sockeye Salmon	9.47	12.73	8.66
Steelhead Trout	2.85	3.80	2.68

others were wildly off-target (sockeye salmon migrating to both dams, yearling chinook and steelhead trout to Rock Island Dam). The largest MADs are probably explained by large, sudden hatchery releases which caused the characteristic smoothly accumulating patterns of fish passage to be disturbed by large discontinuities, with large releases early in the outmigration probably having the most pronounced effects.

4.0 Discussion

For the third consecutive year since 1997, increased PIT-tagging of wild spring/summer yearling chinook salmon parr in the Snake River drainage system has resulted in an increased number of yearling chinook ESUs included in the RealTime forecasting project of predicting fish passage to Lower Granite Dam. This year the RealTime project included nineteen ESUs of spring/summer yearling chinook salmon, four from the Grande Ronde and fifteen from the Salmon River tributaries of the Snake River. Twelve of the sites met the RealTime data requirements of historical releases and observations (section 2.1.1). The seven streams that did not meet the RealTime historical data requirements also performed well on the average and exceptionally well in individual cases, with 3 sites predicting to within 5% of the observed distribution, on average, over the full season. The average whole-season MAD for these sites was 5.2%, compared to an average MAD of 4.0% for the twelve streams which did meet RealTime's data requirements. The year was unremarkable with respect to run-timing characteristics, although most of the runs ended toward the early side of the normal range. Detection rates of PIT-tagged stocks of spring/summer yearling chinook salmon were normal on average, although a few stocks had higher than average detection rates (Big Creek, Camas Creek, Herd Creek, East Fork of the Salmon River, Sulfur Creek, and Valley Creek, Figures A1, A2, A4, A8, A9, Appendix A). These stocks showed a pattern of overprediction similar to that seen in 1998 and described in Burgess, et al. (1999).

Two ESUs of hatchery-reared sockeye from Alturas and Redfish Lakes in Idaho had an unremarkable year with respect to run-timing characteristics in 2000, although with only two years of historical data for Alturas Lake, norms are difficult to established. RealTime performance for Redfish Lake improved over previous years, and recapture percentage and run-timing characteristics were near the historical averages, over five years of data.

Two new PIT-tagged subpopulations of wild Snake River runs-at-large were added to the RealTime forecasting project in 2000. They join the RealTime stock of wild PIT-tagged subyearling fall chinook salmon, first included in 1999. These three PIT-tagged stocks were included to provide run-timing information about the wild runs-at-large which have been dropped from the RealTime project due to lack of passage index data. The Fish Passage Center (FPC) supplied passage indices for these runs in previous years (Townsend et al., 1998, Burgess et al., 1999, Burgess et al., 2000) but new protocols of releasing unmarked hatchery fish into the Snake River have made it impossible for the FPC to distinguish wild from hatchery stocks at Lower Granite Dam. Comparisons of the historical passage distributions of the wild runs at large with the PIT-tagged subpopulations are available at the world-wide website address *www.cbr.washington.edu/crisprt/info.htm.* The ESU of wild PIT-tagged subyearling fall chinook salmon was predicted to within 5% (whole-season MAD = 4.5%) of the observed distribution, on average, over the outmigration season. The new ESU stock of wild PIT-tagged Snake River steelhead trout performed moderately well in 2000, particularly during the last half of the season, contributing to a good season-wide MAD of 4.8%. The poorer first half performance (first-half MAD = 10.8%) of this stock is probably due to the unusually large run size in 2000 (Table 4), a condition associated with early over-prediction (see Burgess, et al., 1999 for explanation). The aggregate stock of Clearwater River (non-ESU) and Snake River (ESU) wild PIT-tagged spring/summer yearling chinook salmon was predicted to within 2% of the true distribution, on average, over the whole season, with a season-wide MAD of 1.7%.

New to the project in 2000 were ten runs-at-large of salmonids migrating to Rock Island Dam on the mid-Columbia River and to McNary Dam on the Columbia River. Program RealTime tracked and forecasted combined wild and hatchery subyearling chinook, yearling chinook, coho and sockeye salmon, and steelhead trout to each dam. The forecaster's performance was probably largely determined by whether or not large releases of hatchery fish caused unpredictable discontinuities in the cumulative percentage curves of observed passage. Several of the runs were predicted with exceptional accuracy, including the coho salmon runs to both dams, and the yearling chinook salmon run to McNary Dam. All three were predicted to within 1% of the observed distributions, on average, across the season. Two of the five mid-Columbia runs (to Rock Island Dam) and four of the Columbia runs (to McNary Dam) were predicted to within 4% accuracy, on average, over the season. But sockeye salmon runs to both dams, as well the yearling chinook salmon and steelhead trout runs to Rock Island Dam, failed to predict even to within 10% accuracy of the observed distributions (see Appendix A, Figures A14-A18).

5.0 Recommendations

Additional refinements to the RealTime project of forecasting run-timing and passage distribution of ESA-listed species of salmonids outmigrating to Lower Granite are recommended in order to improve the reliability of inseason predictions made by Program RealTime. These efforts include *a)* utilization of a new calibration procedure developed for Program RealTime during the migration year 2000 post-season analysis (Burgess and Skalski, 2000b), *b)* continued monitoring and utilization of research results affecting our count adjustment process. The count adjustment process expands raw PIT-tag detections proportionately to the fraction of smolts using routes of passage not equipped with PIT-tagged detectors, such as the spillway at Lower Granite Dam. Upwardly adjusting raw PIT-tag detections for undetected dam passage may increase the accuracy of predictions by increasing the accuracy of the data used by program RealTime.

5.1 RealTime Calibration

We recommend that results obtained this year from a study into the effectiveness of calibrating the RealTime Program for individual stocks (Burgess and Skalski, 2000b) be utilized during the 2001 and future outmigrations of salmonid smolts in the Snake, mid-Columbia, and Columbia Rivers. The calibration routine optimizes model-switching parameters that help govern the timing of the switch from run-percentage predictions to pattern-matching predictions (Section 2.6). The 2000 calibation study showed that optimizing switching parameters for individual stocks is highly effective with regard to increased accuracy and precision of predictions for some stocks. Any stocks new to the 2001 RealTime forecasting project will be calibrated prior to forecasting. In addition, the calibration routine will be performed each year, thereby incorporating the previous year's information into the historical data for each stock.

5.2 Adjustment of Data

Research has shown that different salmonid species have different characteristics of passage through hydroelectric projects, and, additionally, there is variation among hydroelectric projects with respect to these characteristics. Passage efficiencies are also affected by environmental variables such as temperature and flow volume. Continued monitoring and evaluation of research into these important questions affecting passage at Lower Granite dam and fish count adjustments is recommended.

6.0 Conclusions and Summary

The performance of program RealTime in predicting passage percentages and forecasting run-timing characteristics was very good, overall, in 2000. Season-wide and last-half performance improved over previous years for the spring/summer yearling chinook salmon ESUs, which included more individual stocks than any previous year, including several streams that did not meet the original historical data criteria for Program RealTime. First-half predictions had slightly higher all-site average MAD in 2000 compared to 1999. The reason for larger first-half MADs in 2000 was that some stocks showed larger-than-average numbers of smolts detected at Lower Granite Dam. On average, however, detection rates were unremarkable, and within the range of normal. Run-timing characteristics were also, on the whole, unremarkable, and 2000 was considered a standard flow year. RealTime's forecasting of run-timing for the ESU of hatchery-reared summer-run sockeye salmon from Redfish Lake has continued to improve, with 2000 performance the best on record. A second sockeye stock was included in the project this year, from Alturas Lake, and it was predicted well based on its two years of historical data.

Program RealTime performance for three PIT-tagged subpopulations of wild runs-at-large of yearling and subyearling chinook salmon and steelhead trout was good (within 5% of the observed distributions for season, for all three stocks). The steelhead trout stock had the highest number of detections on record and the associated over-prediction by Program RealTime was apparent for this stock. Two of the PIT-tagged subpopulation were new to the RealTime project this year (yearling chinook salmon and steelhead trout). The other stock, PIT-tagged subyearling chinook salmon, was in its second year of forecasting in the 2000 RealTime project. All three stocks were included to provide run-timing information for the discontinued wild runs-at-large of passage indices, previously provided by the FPC. The wild runs-at-large are no longer tallied separately from hatchery fish, as hatcheries currently release their fish unmarked. While the performance of the RealTime forecaster in predicting passage of these PIT-tagged stocks is quite good, it is not certain how valuable these predictions apply to predicting the runs-at-large themselves.

Ten runs-at-large, five each to Rock Island Dam and McNary Dam, were tracked and forecasted by Program RealTime for the first time in 2000. The runs included the combined wild and hatchery runs of subyearling and yearling chinook, coho and sockeye salmon, and steelhead trout. Several runs (coho salmon migrating to both Rock Island and McNary Dams, and yearling chinook migrating to McNary) were predicted exceptionally well, to within 2% of the observed distribution season-wide, on average. On the other hand, several failed to be predicted to within 10% during the first half of the outmigration (sockeye salmon outmigrating to both dams, and subyearling chinook and steelhead trout migrating to Rock Island Dam). Poor predictions during the first half are probably due to large hatchery releases occurring early in the season, causing disturbances to the continuity of normal cumulative passage of smolts outmigrating to index points.

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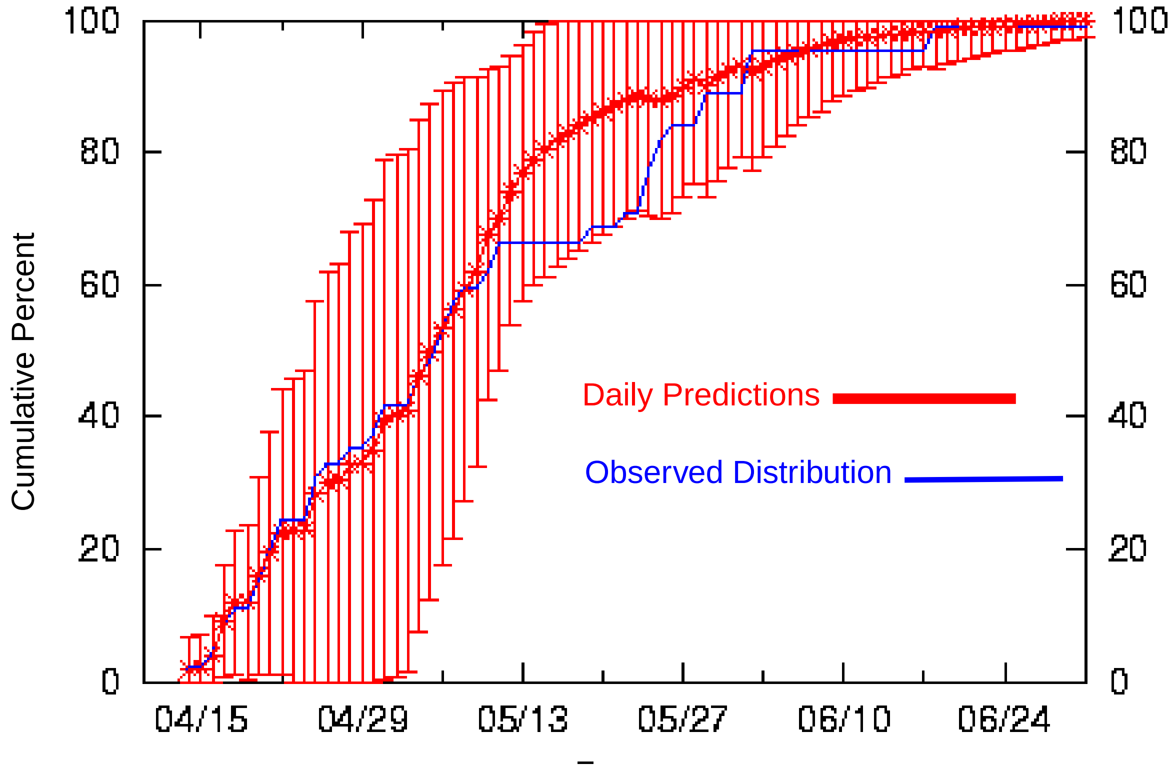
Appendix A

<u>Performance Plots for the 2000 Out-migration Season</u>

Figure A1: Bear Valley Creek and Big Creek Daily Predictions

Bear Valley Creek



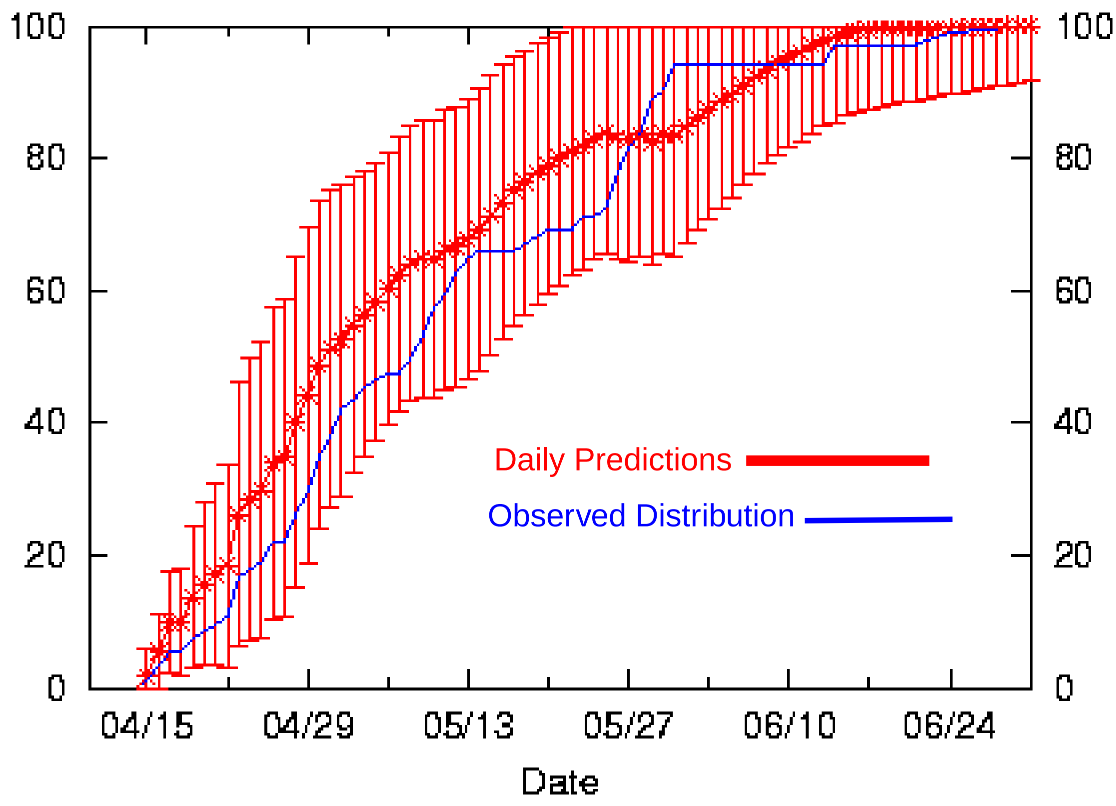
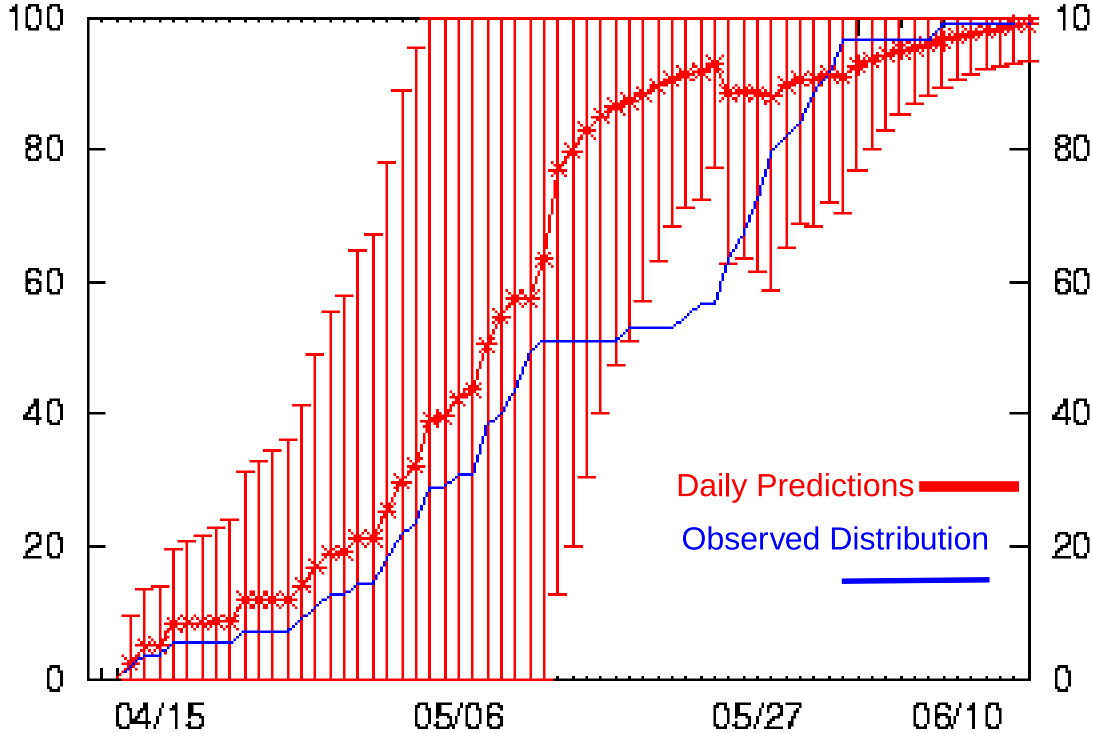


Figure A2: Camas Creek and CapeHorn Creek Daily Predictions

Camas Creek



Cape Horn Creek

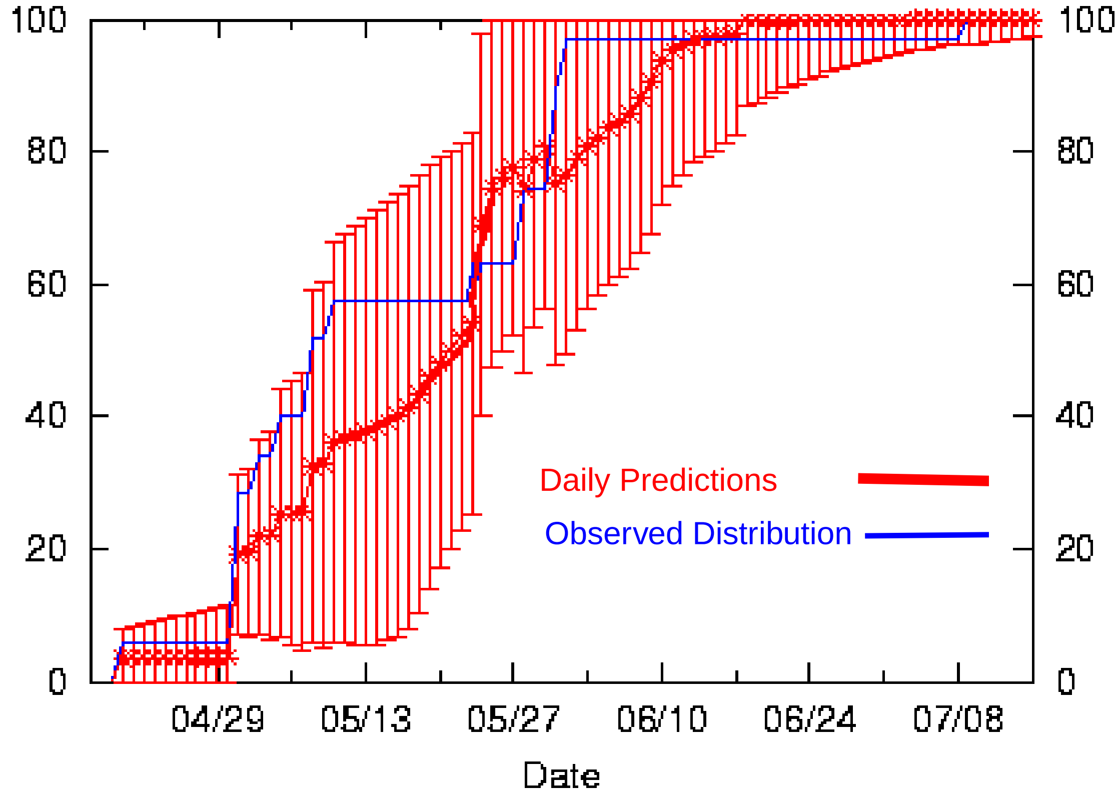
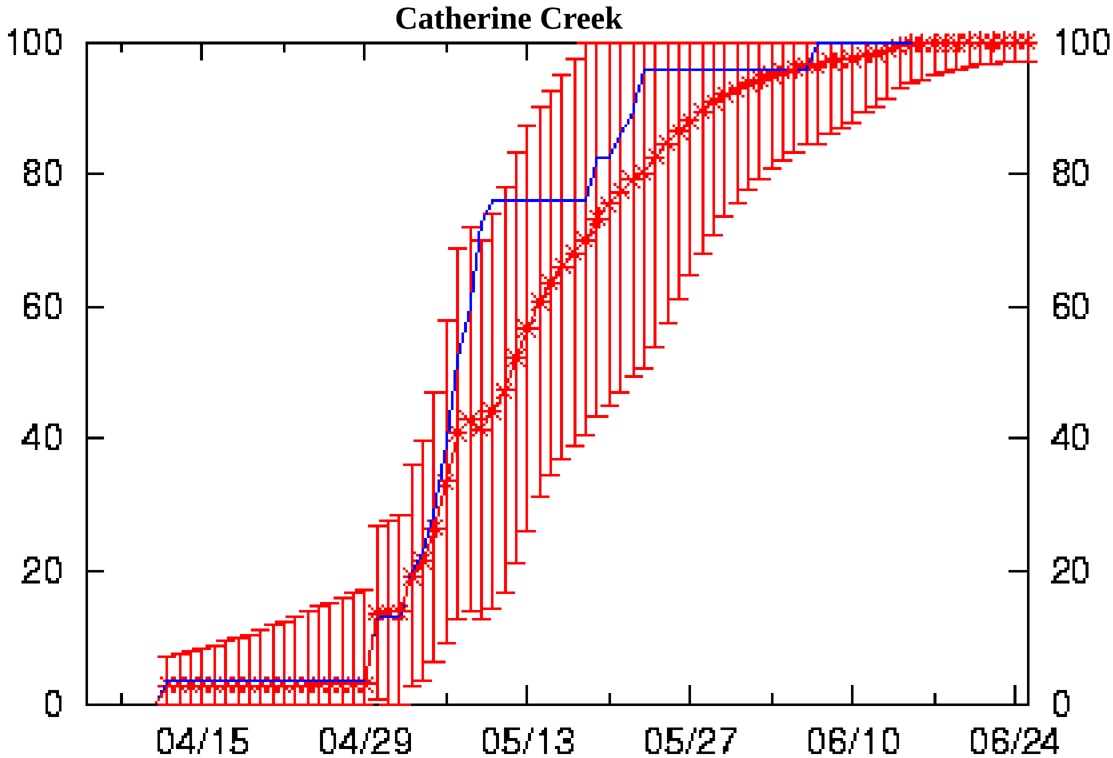


Figure A3: Catherine Creek and Elk Creek Daily Predictions



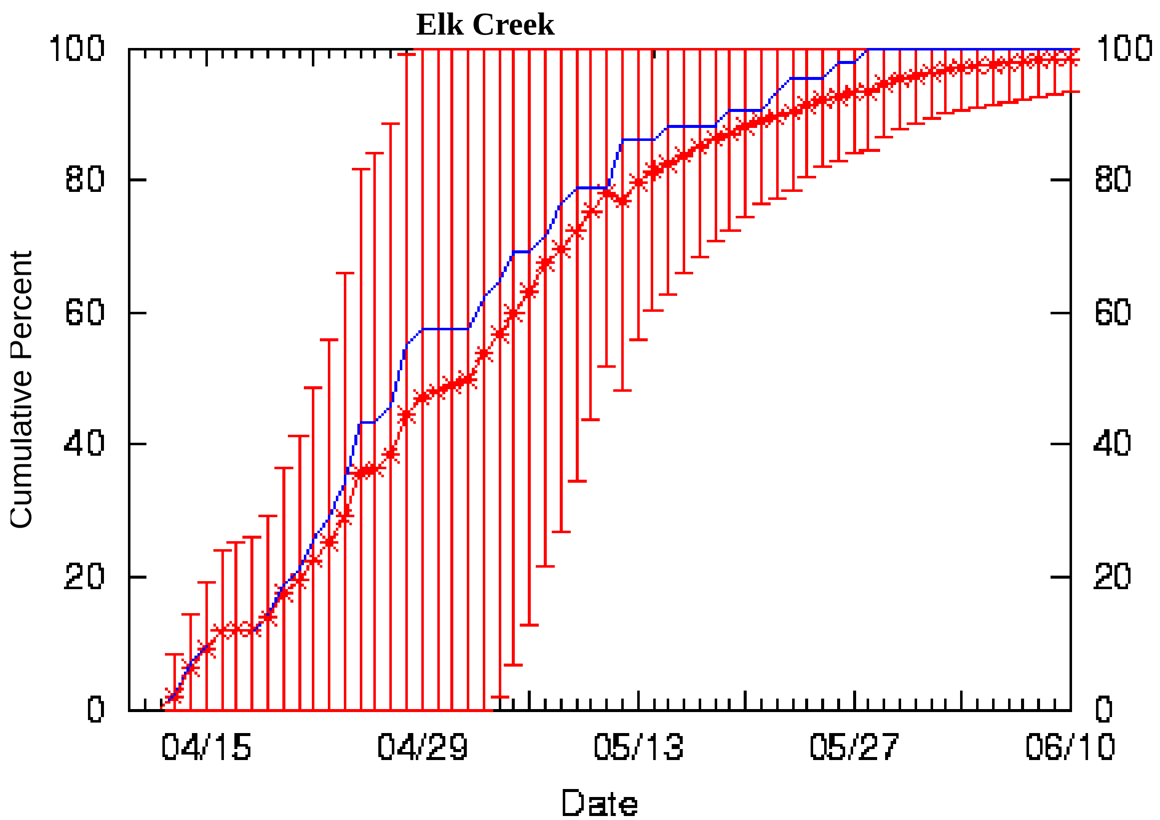


Figure A4: Herd Creek and Imnaha River Daily Predictions

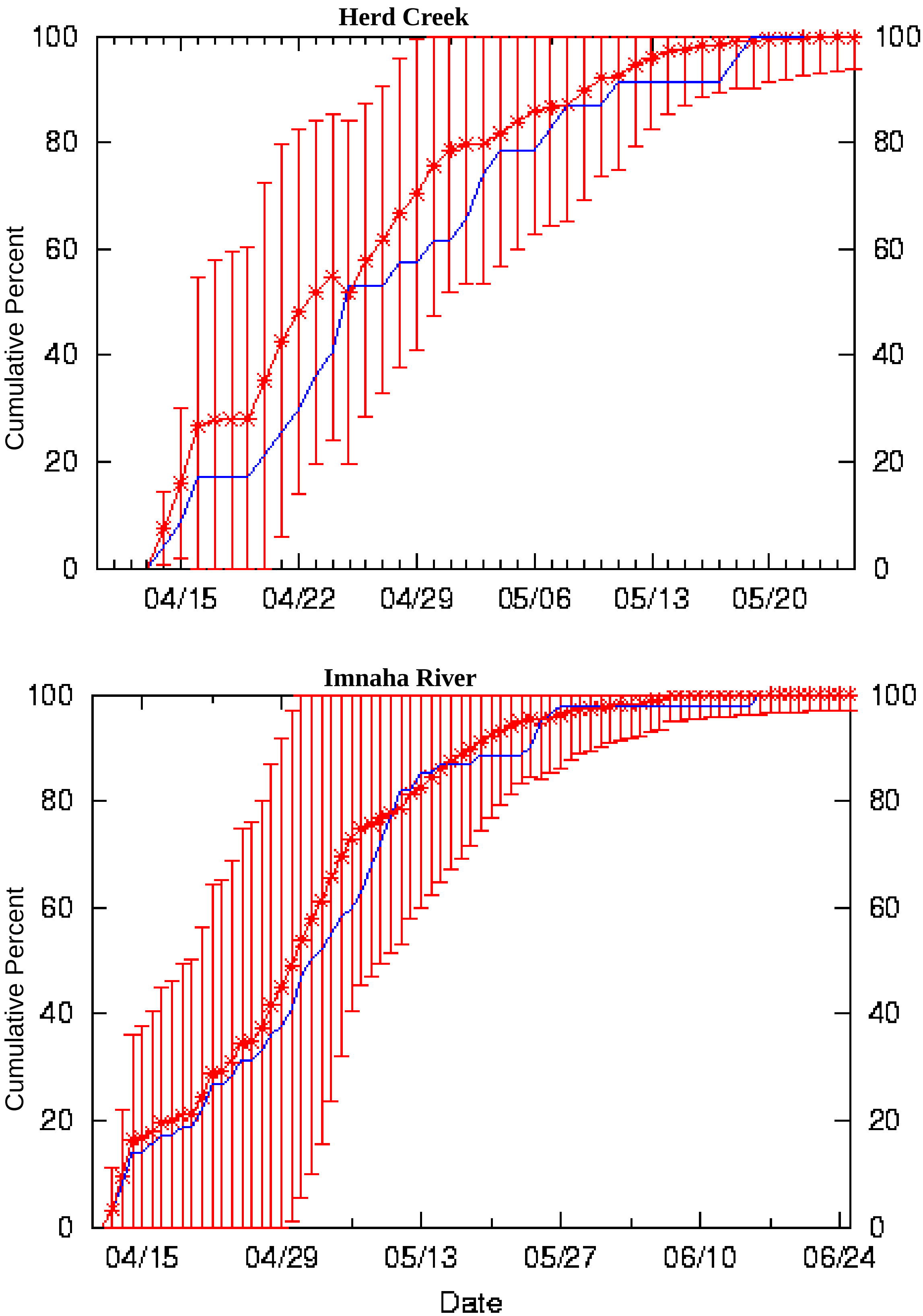


Figure A5: Johnson Creek and Lake Creek Daily Predictions

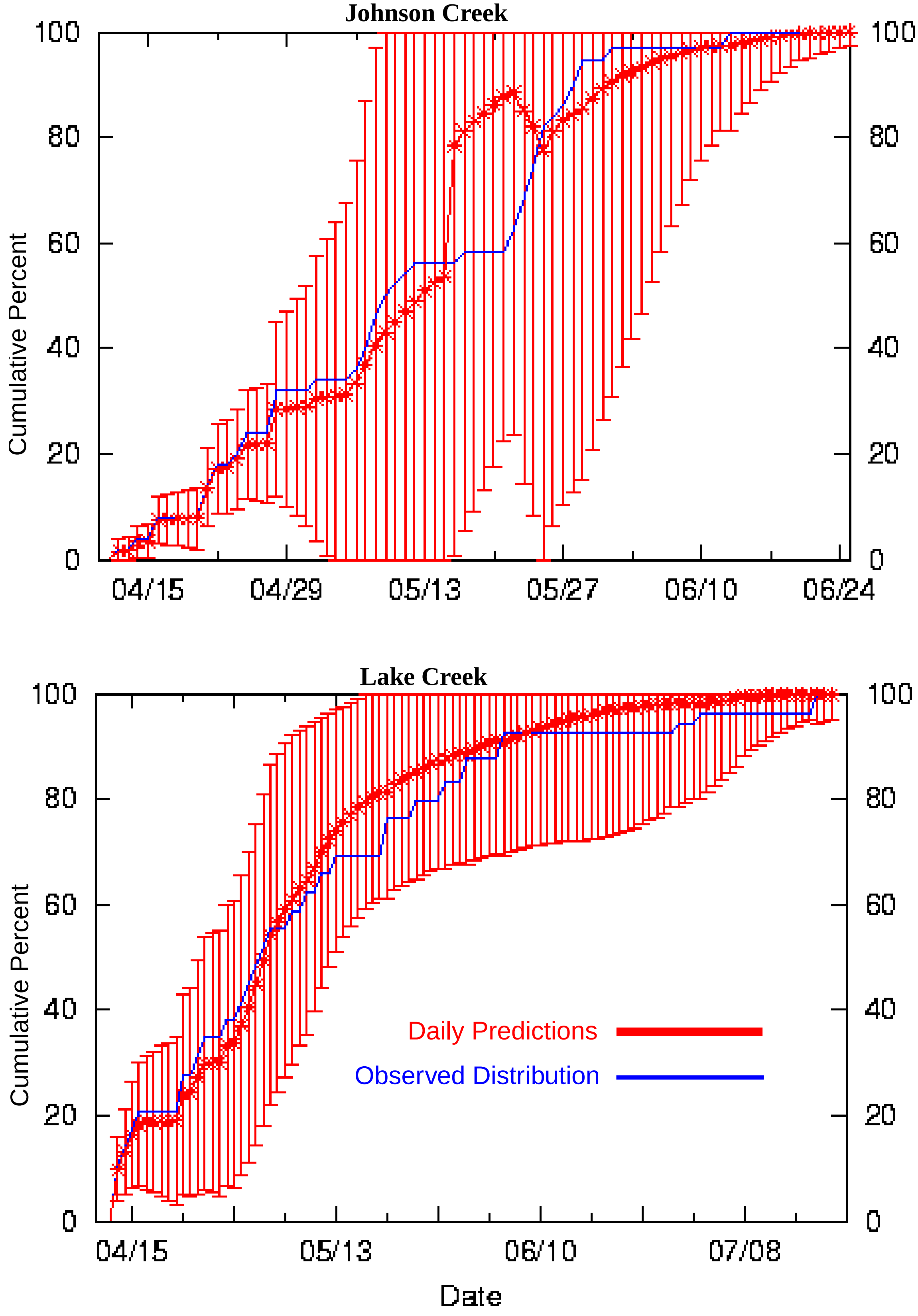
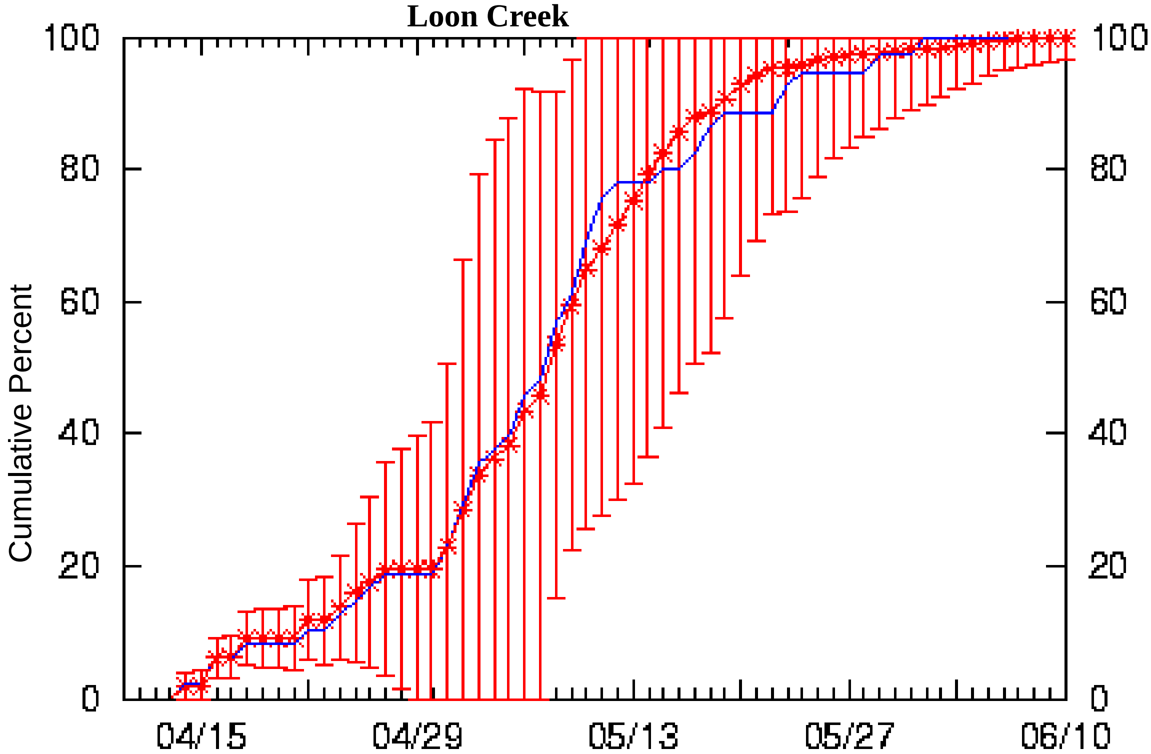


Figure A6: Loon Creek and Lostine River Daily Predictions



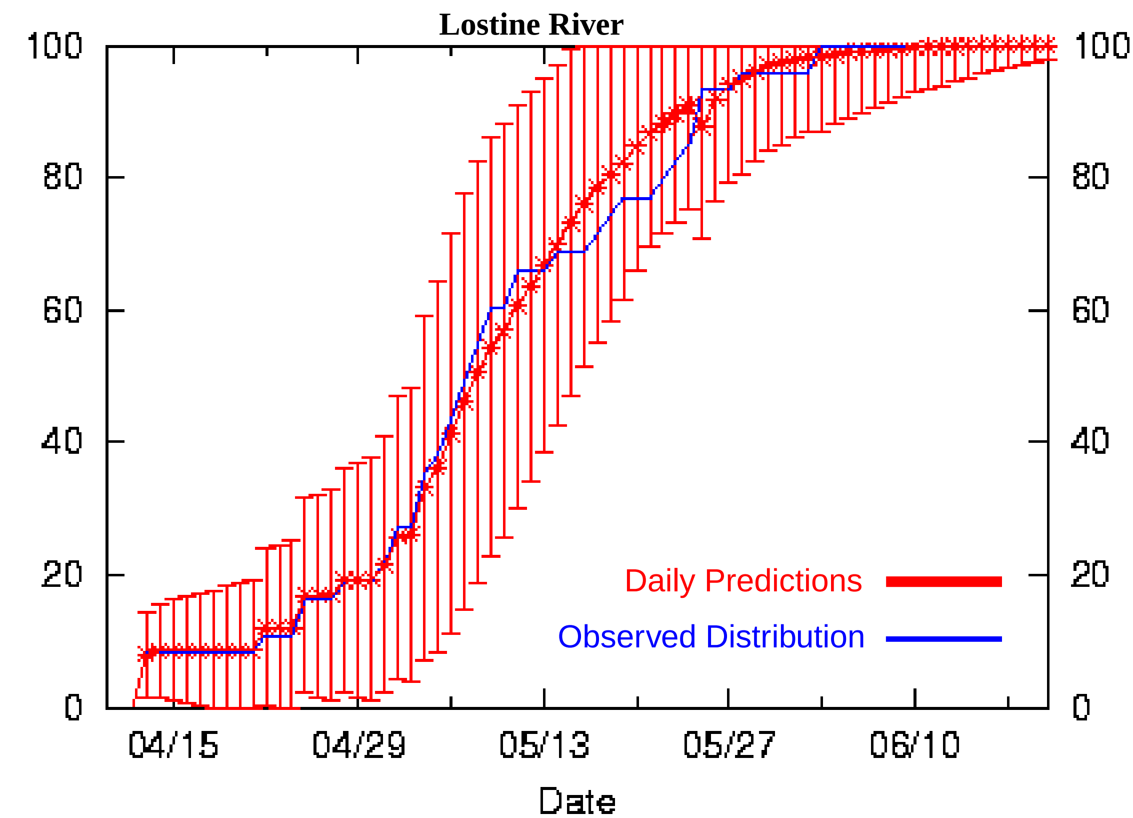


Figure A7: Marsh Creek and Minam River Daily Predictions

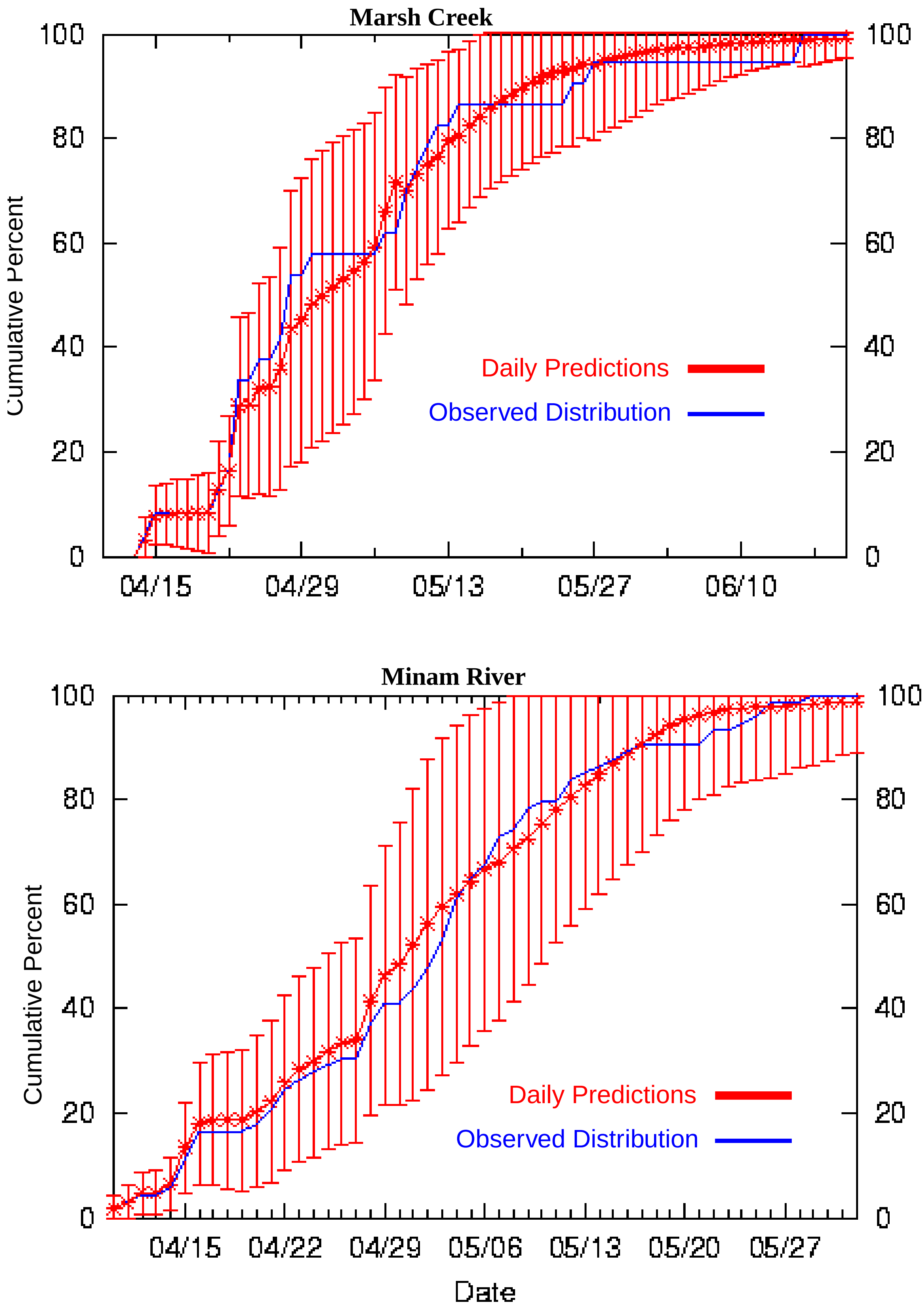
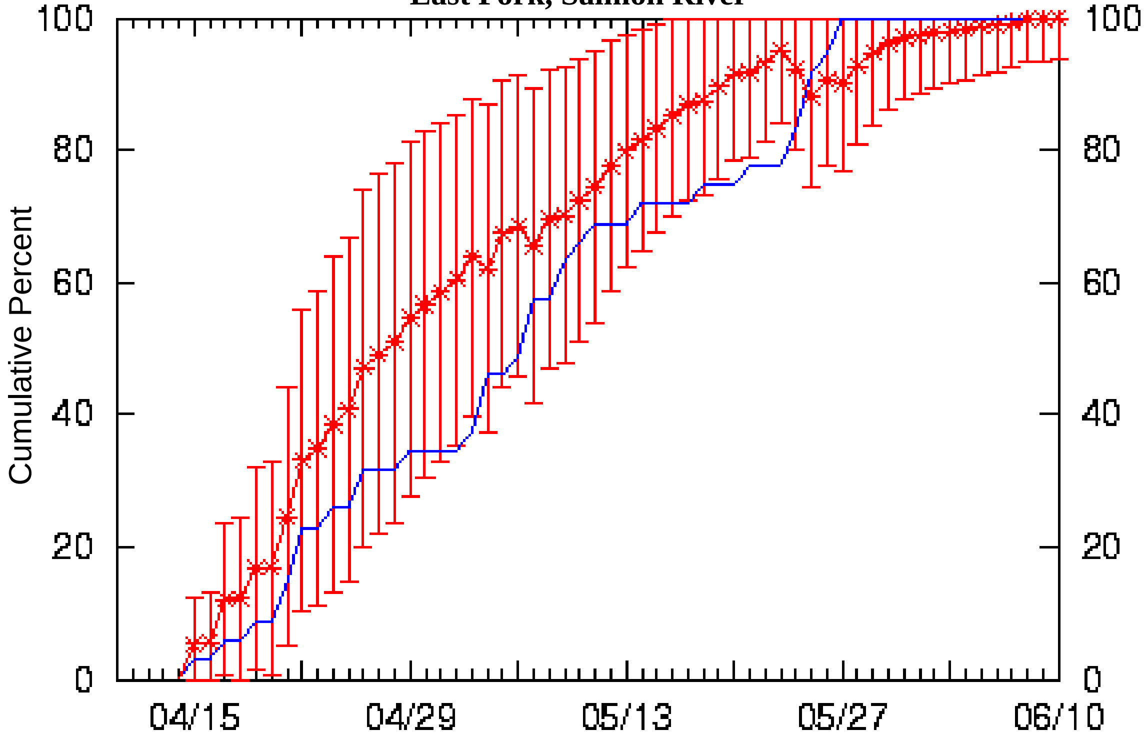


Figure A8: East Fork Salmon River and South Fork Salmon River Daily Predictions

East Fork, Salmon River



South Fork, Salmon River

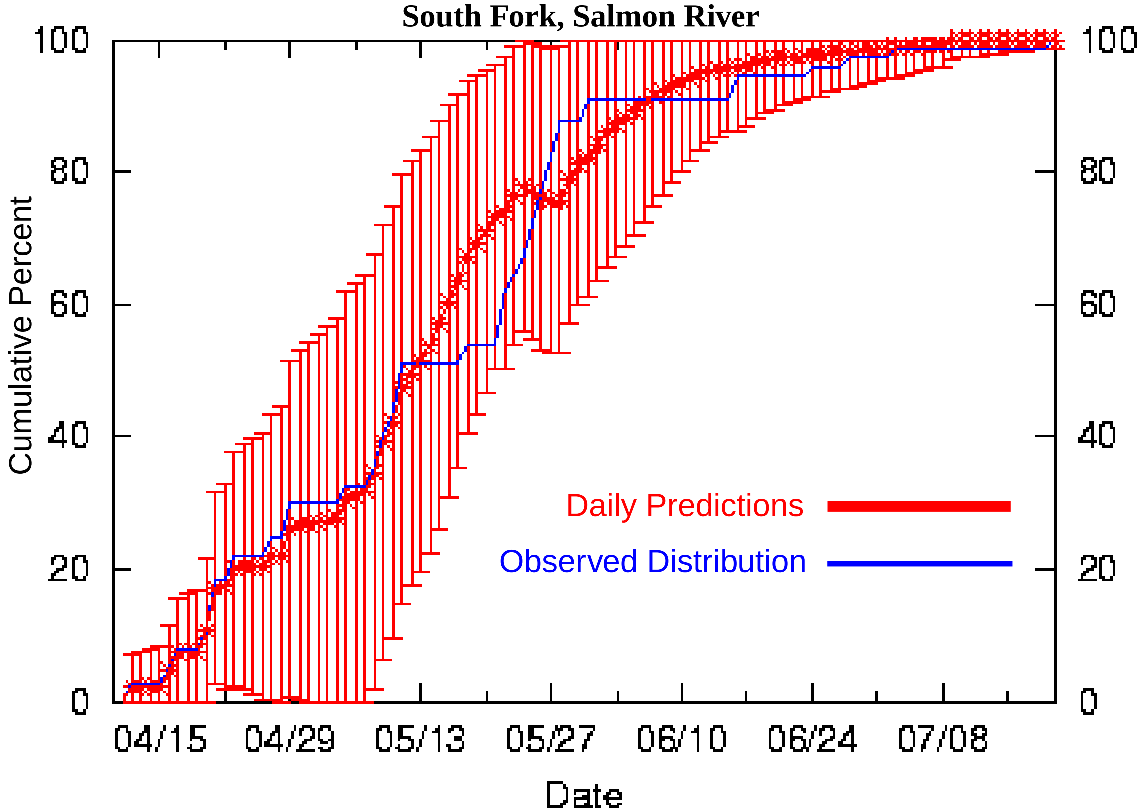
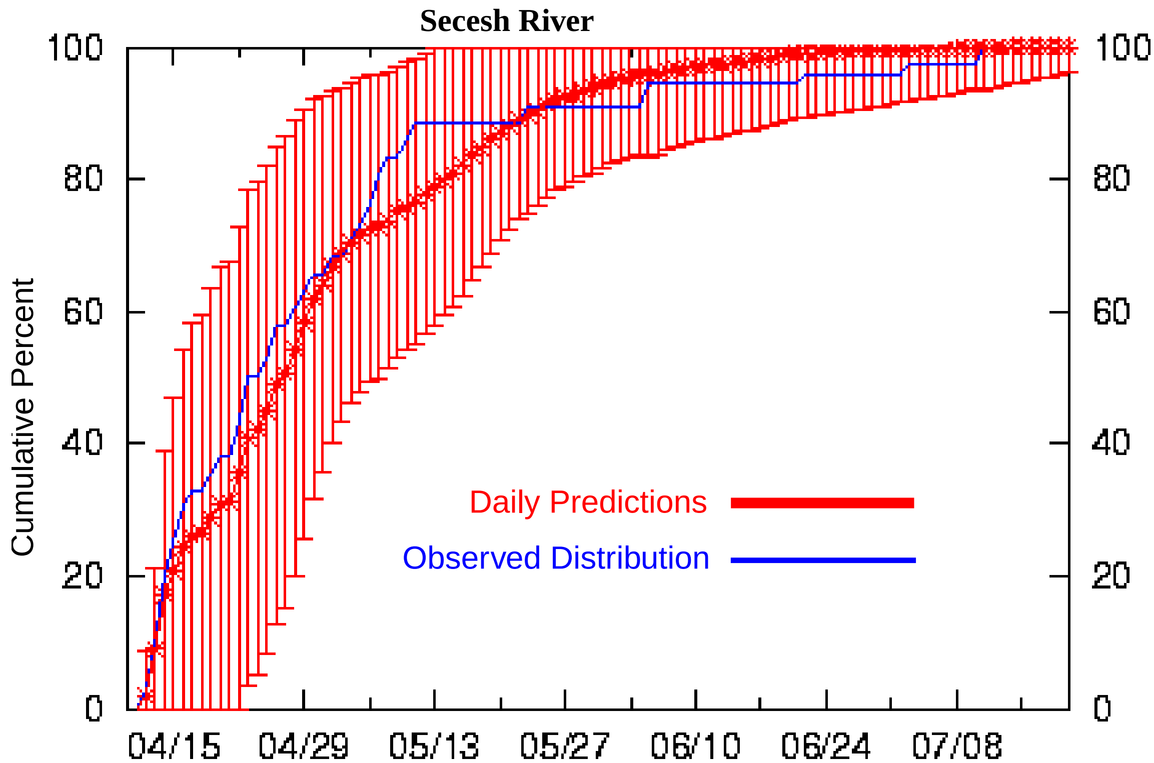


Figure A9: Secesh River and Sulfur Creek Daily Predictions



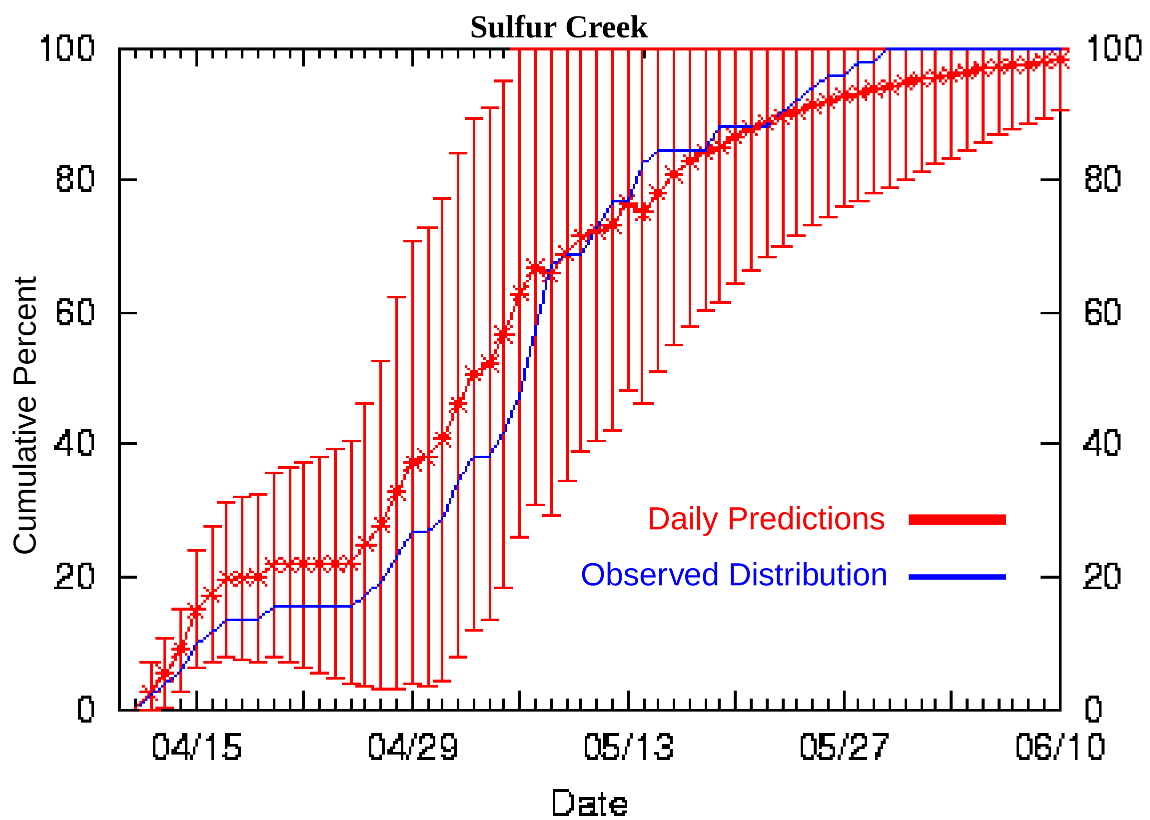


Figure A10: Valley Creek Daily Predictions

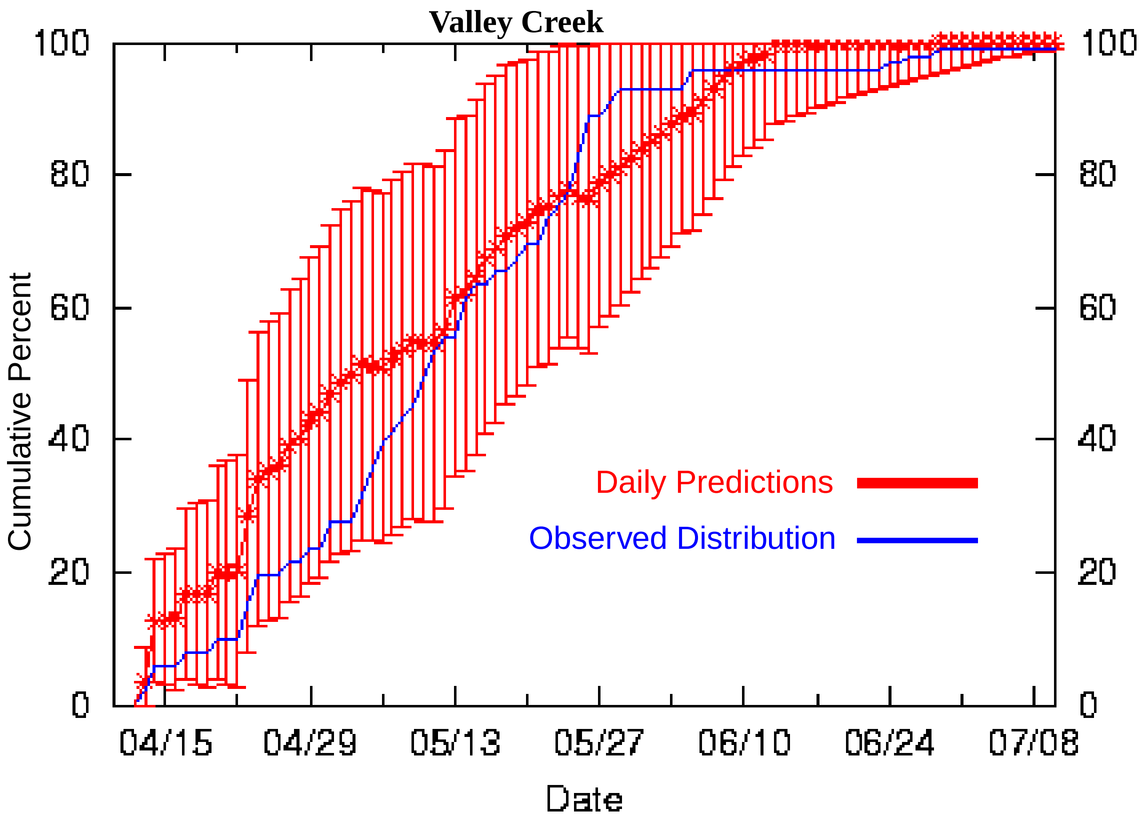
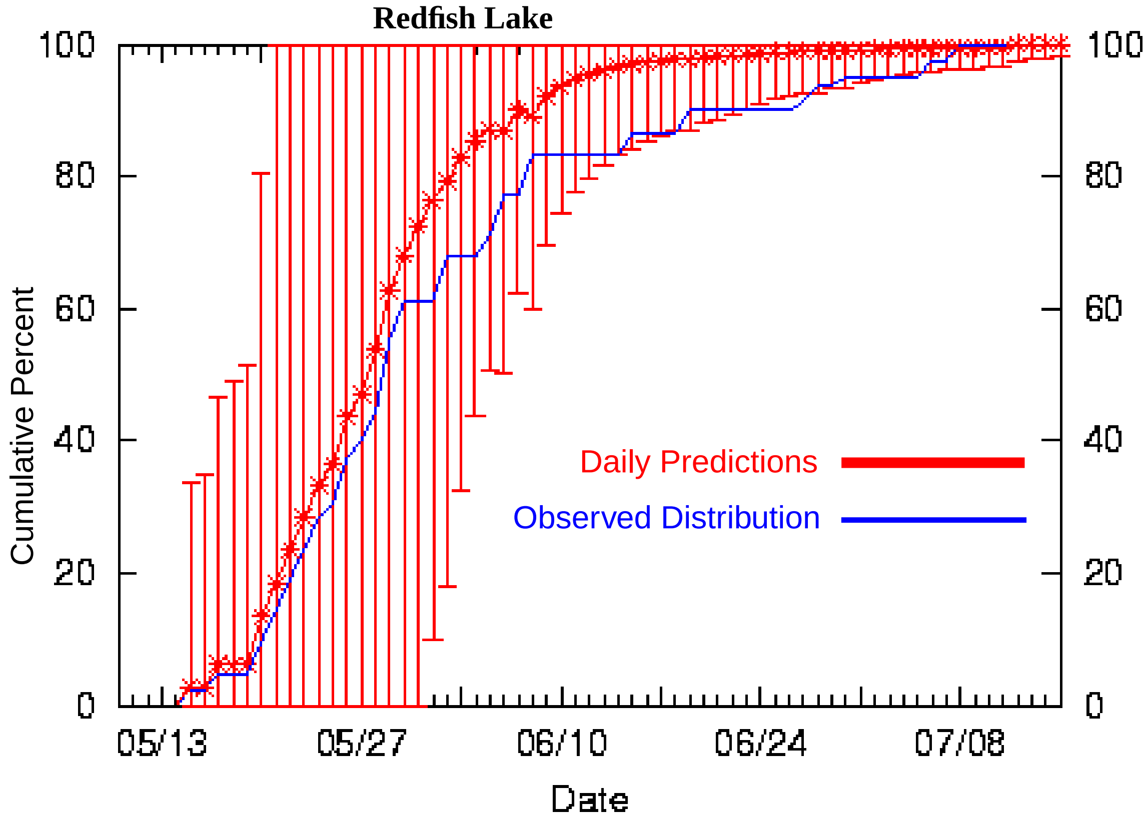


Figure A11: Alturas Lake and Redfish Lake Daily Predictions



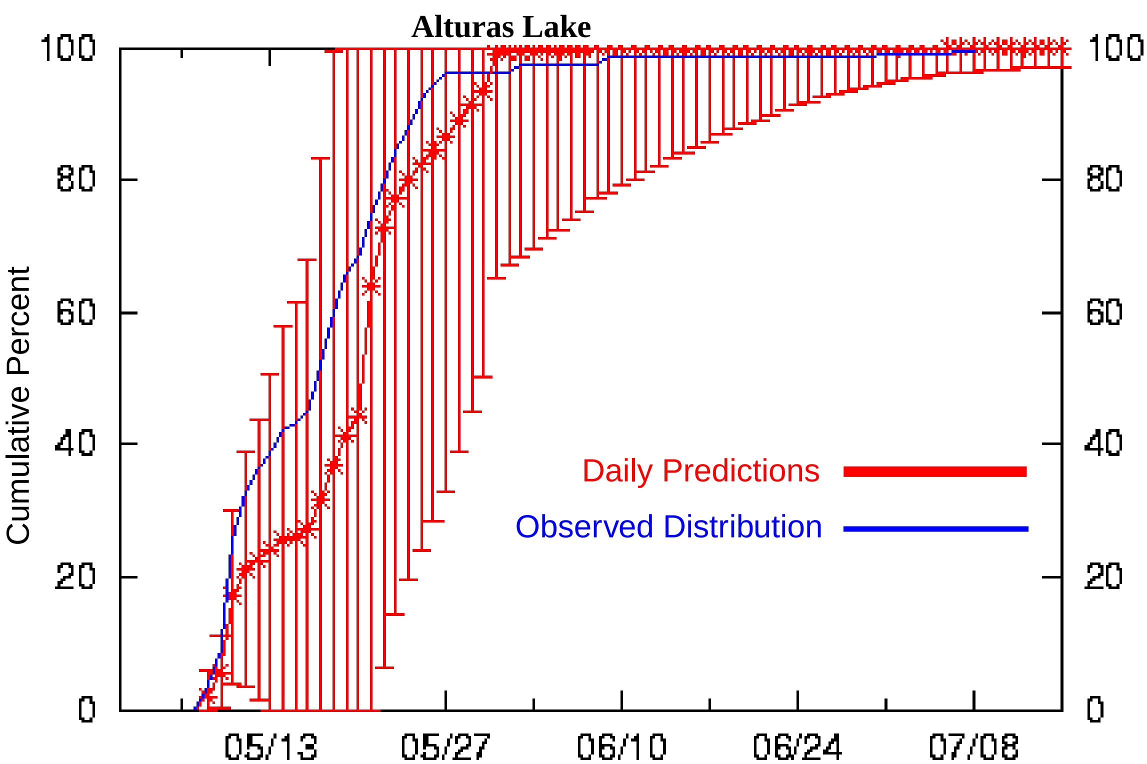
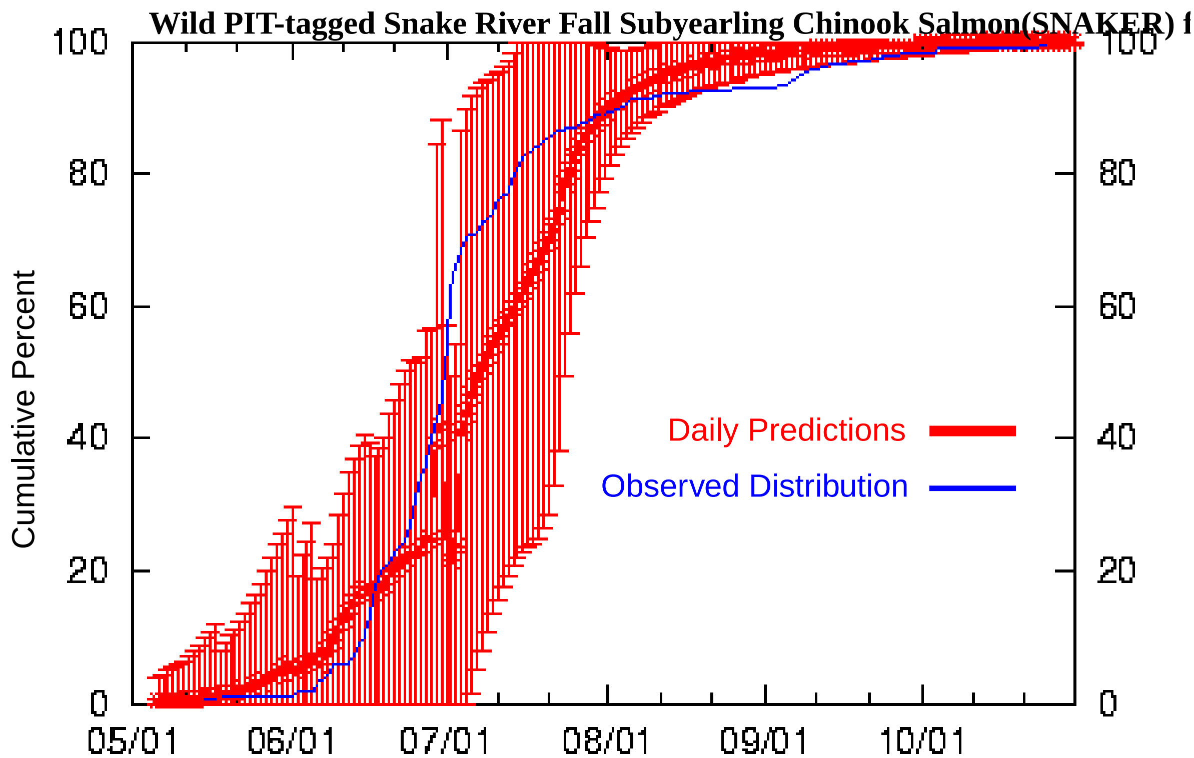


Figure A12: Wild PIT tagged Snake River Subyearling Chinook Salmon and Steelhead Trout Daily Predictions,



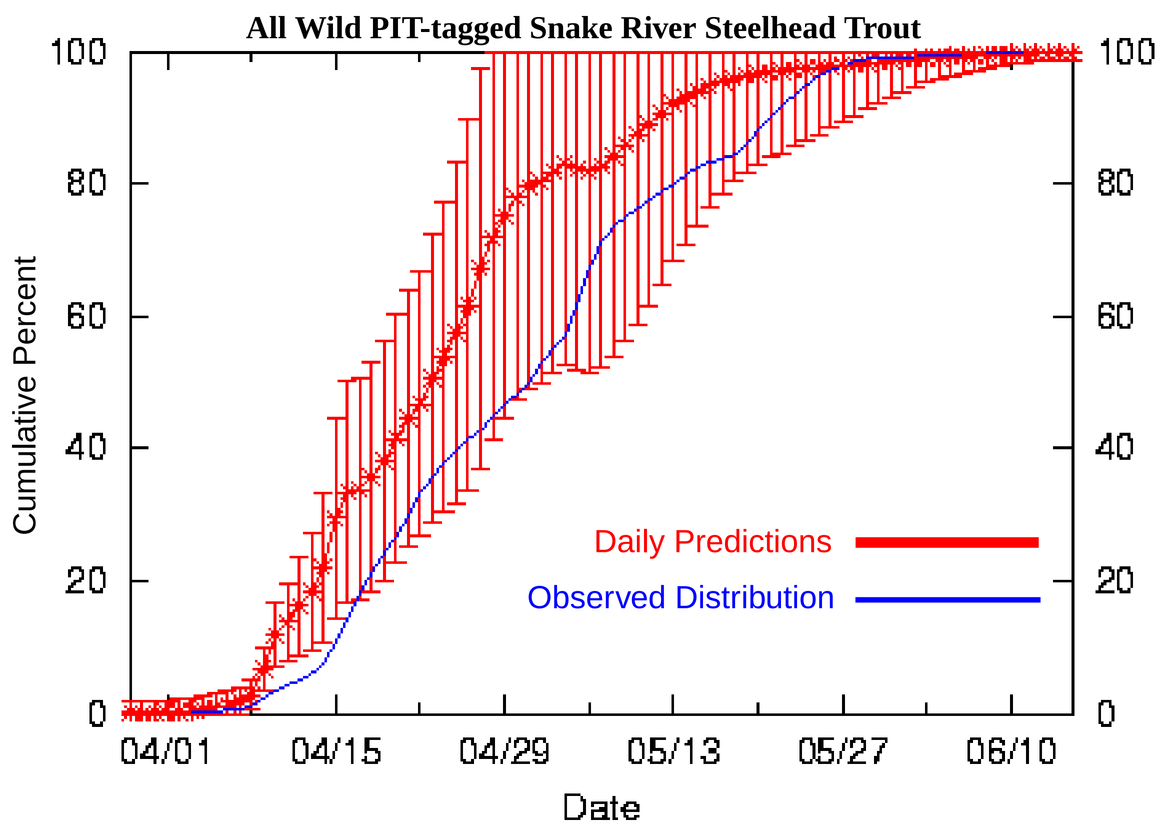


Figure A13: Wild PIT-tagged Snake River Yearling Chinook Salmon Daily Predictions

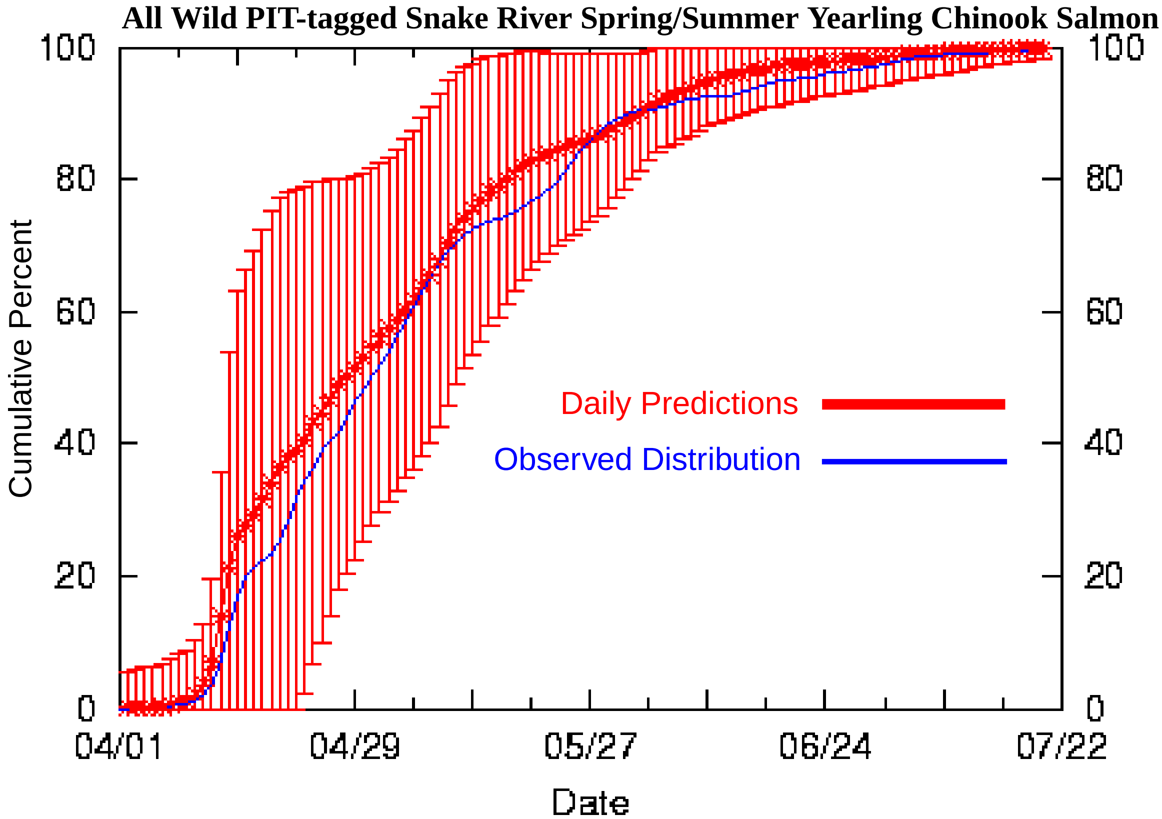
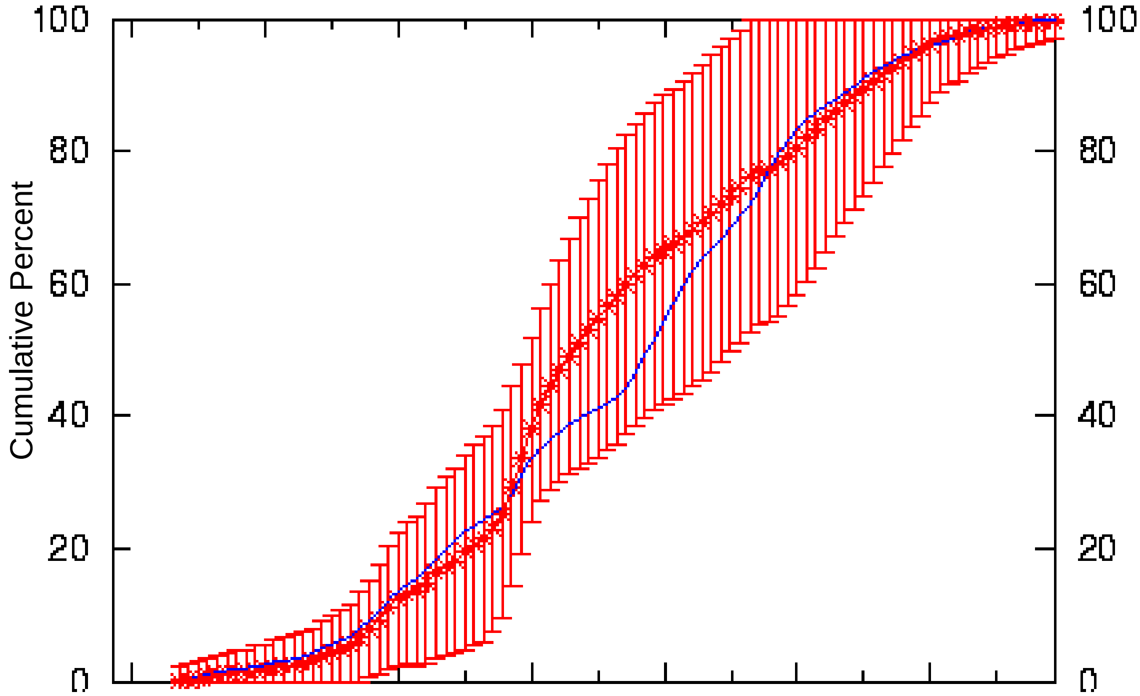


Figure A14: Combined Wild and Hatchery Subyearling and Yearling Chinook Salmon Daily Predictions at Rock Island Dam.

Combined Wild and Hatchery Subyearling Chinook at Rock Island Dam



Combined Wild and Hatchery Yearling Chinook at Rock Island Dam

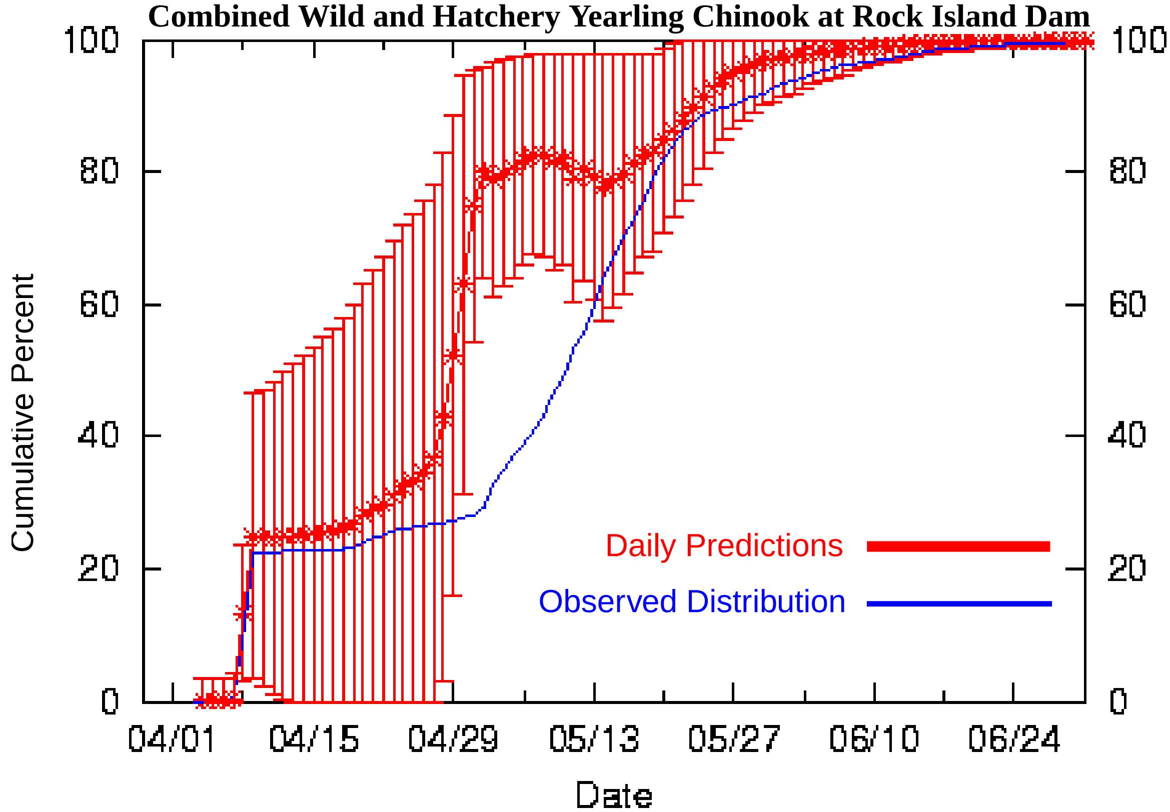


Figure A15: Combined Wild and Hatchery Coho and Sockeye Salmon Daily Predictions at Rock Island Dam.

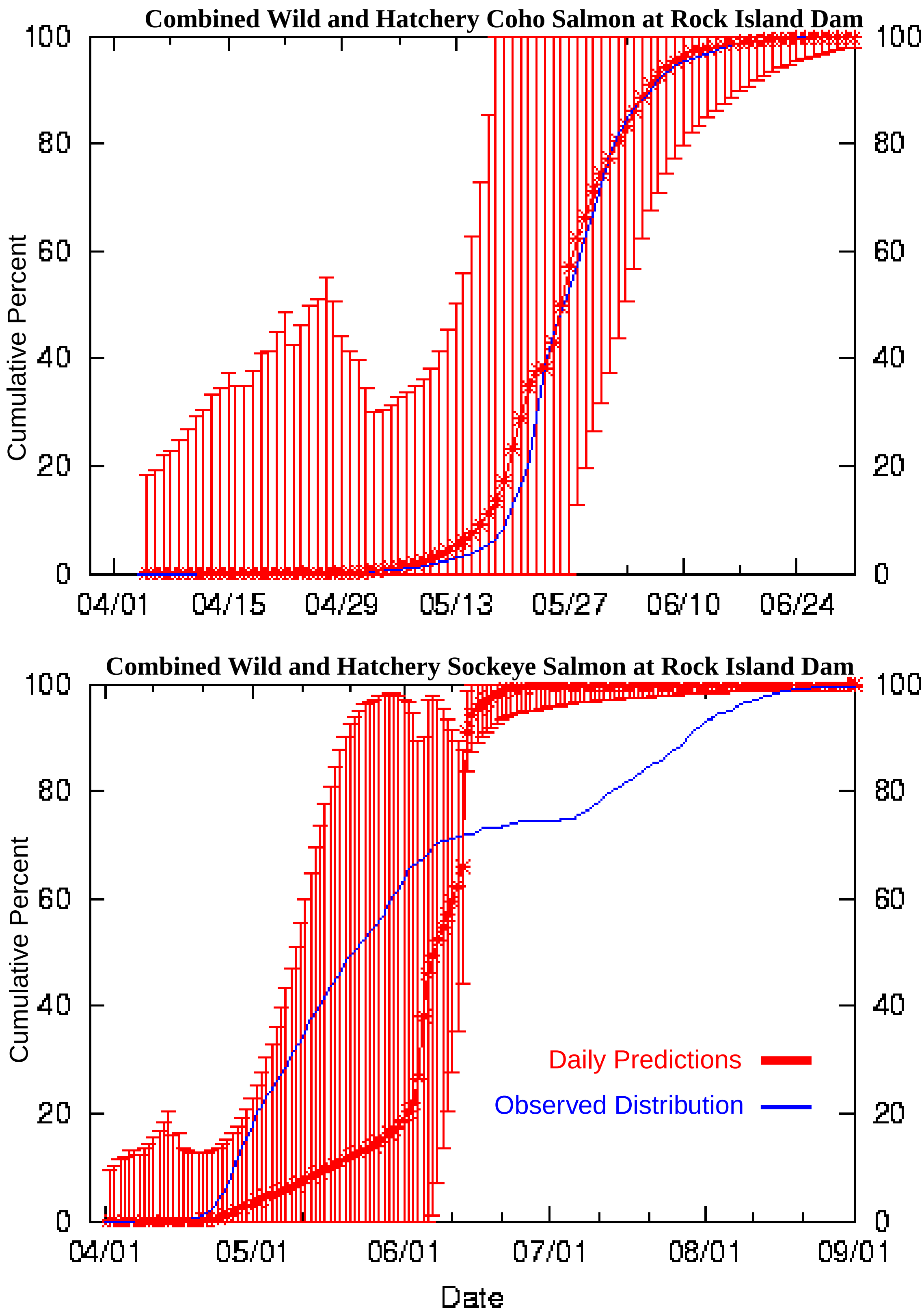
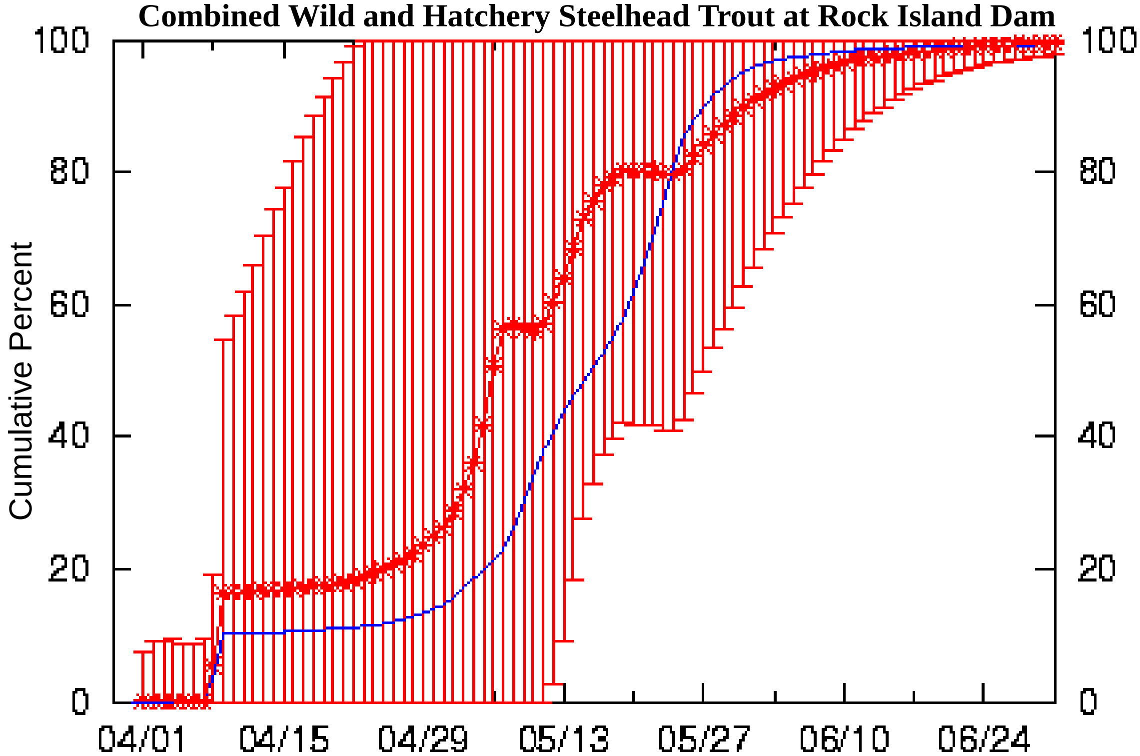


Figure A16: Combined Wild and Hatchery Steelhead Trout Daily Predictions at Rock Island Dam and Subyearling Chinook Salmon Daily Predictions at McNary Dam.



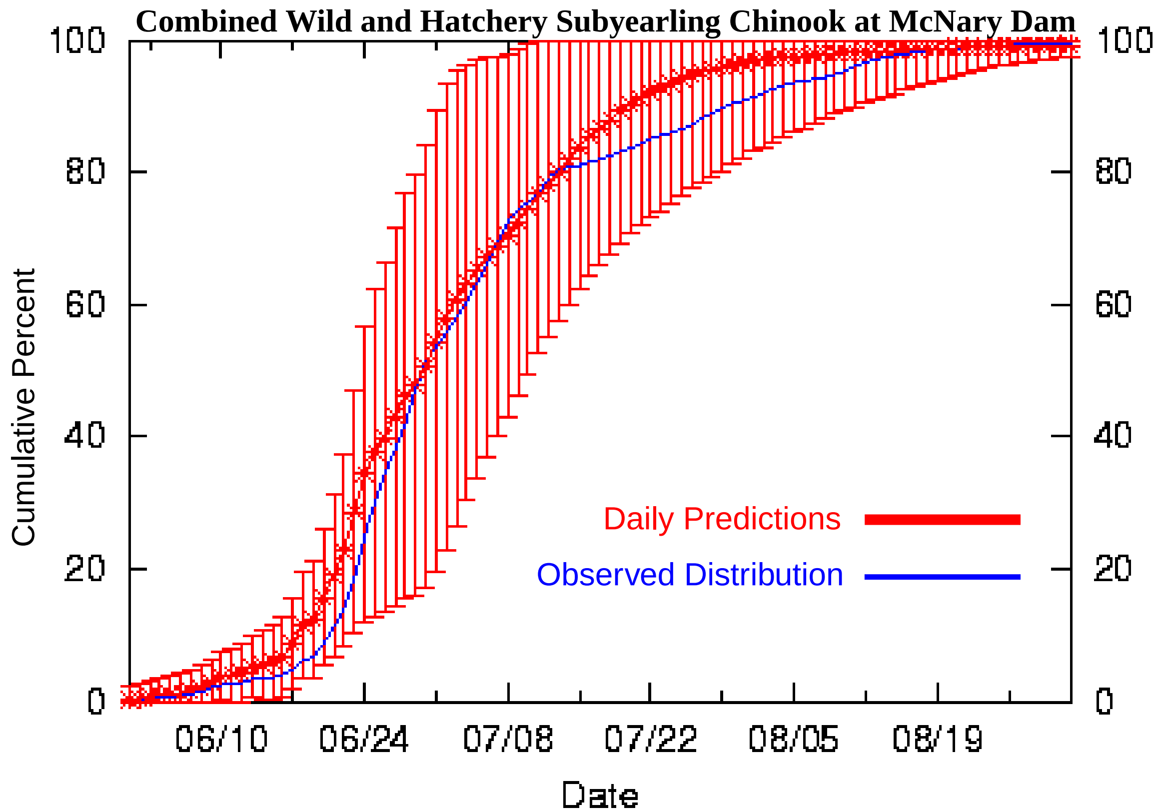


Figure A17: Combined Wild and Hatchery Yearling Chinook and Coho Salmon Daily Predictions at McNary Dam.

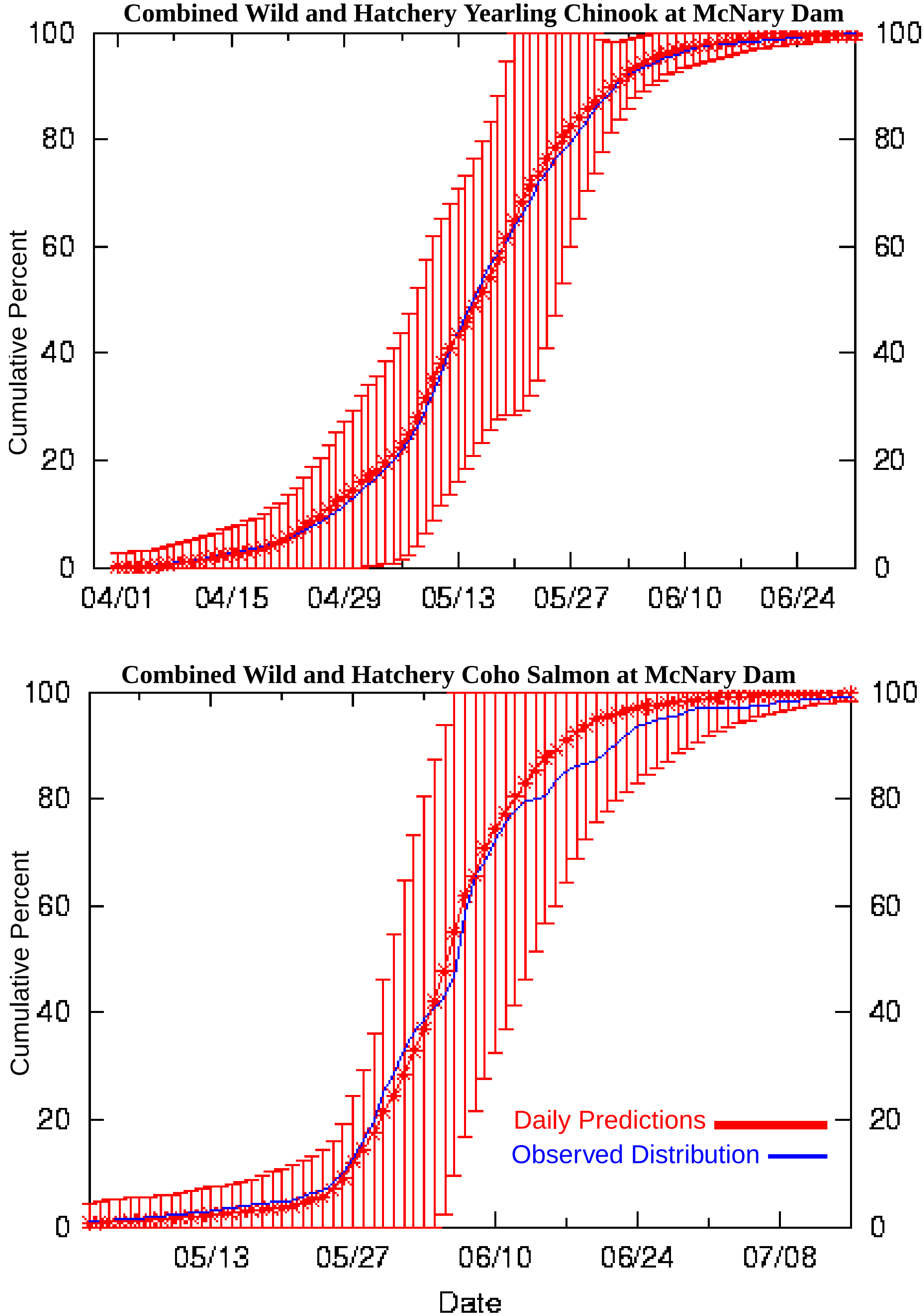
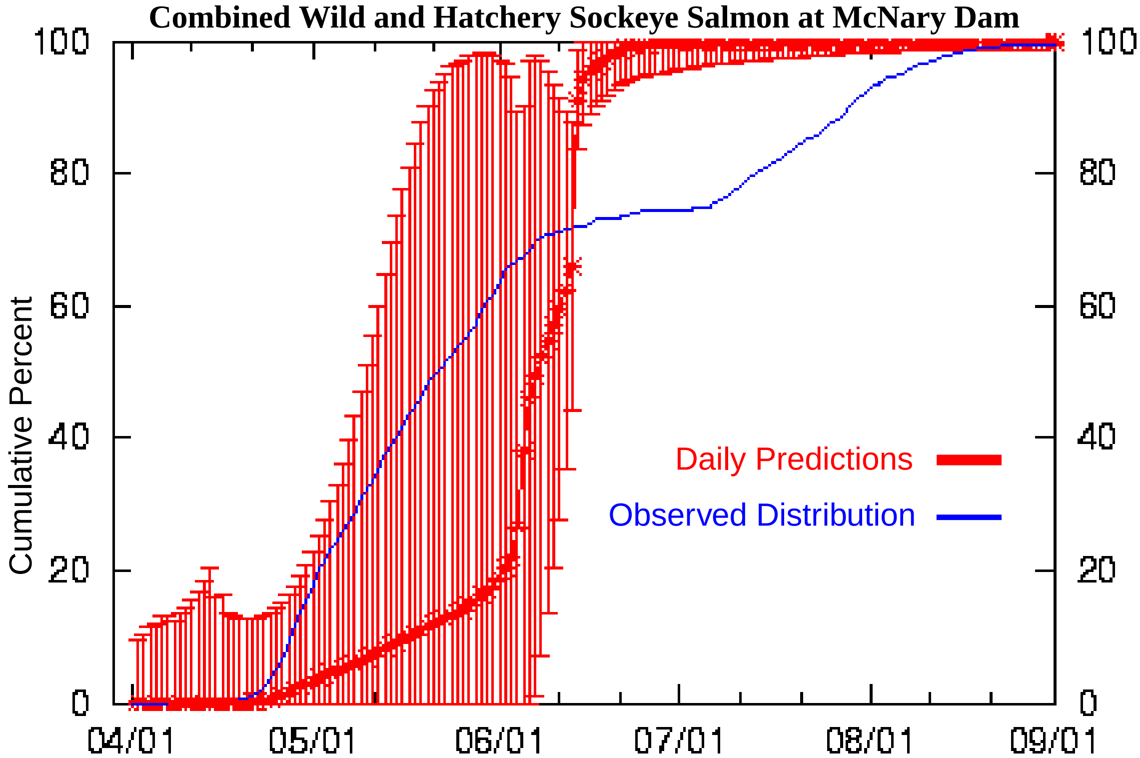
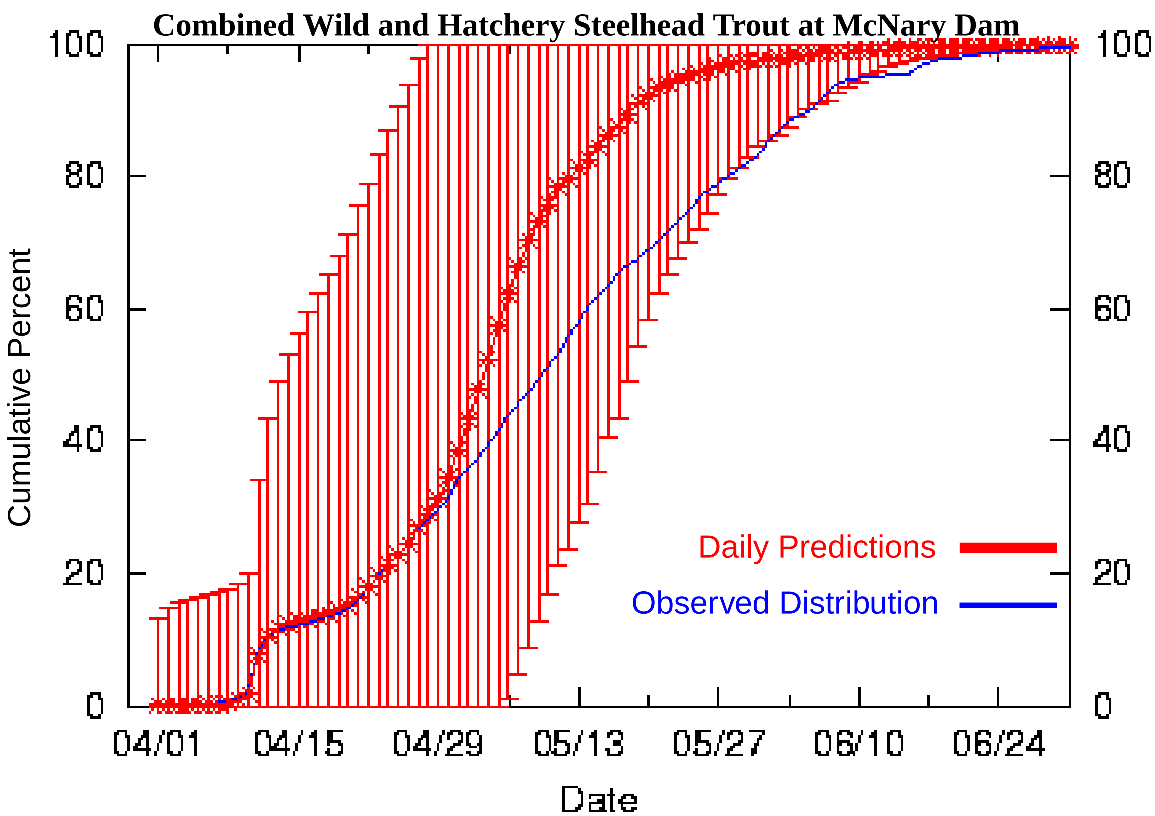


Figure A18: Combined Wild and Hatchery Sockeye Salmon and Steelhead Trout Daily Predictions at McNary Dam.





Appendix B

Historical timing plots and dates of passage at Lower Granite Dam, Rock Island Dam, and McNary Dam for individual stocks tracked and forecasted by Program RealTime during the 2000 outmigration. Stocks tracked at Lower Granite Dam were wild PIT-tagged yearling and subyearling chinook salmon ESUs, the wild PIT-tagged steelhead trout ESU, the wild PIT-tagged yearling chinook salmon aggregate populution, and hatchery PIT-tagged sockeye salmon ESUs. Stocks tracked at Rock Island and McNary Dam were FPC passage indices of combined wild and hatchery runs-at-large of yearling and subyearling chinook salmon, coho and sockeye salmon, and steelhead trout.

Figure B1: Historical Bear Valley Creek outmigration distribution at Lower Granite Dam.

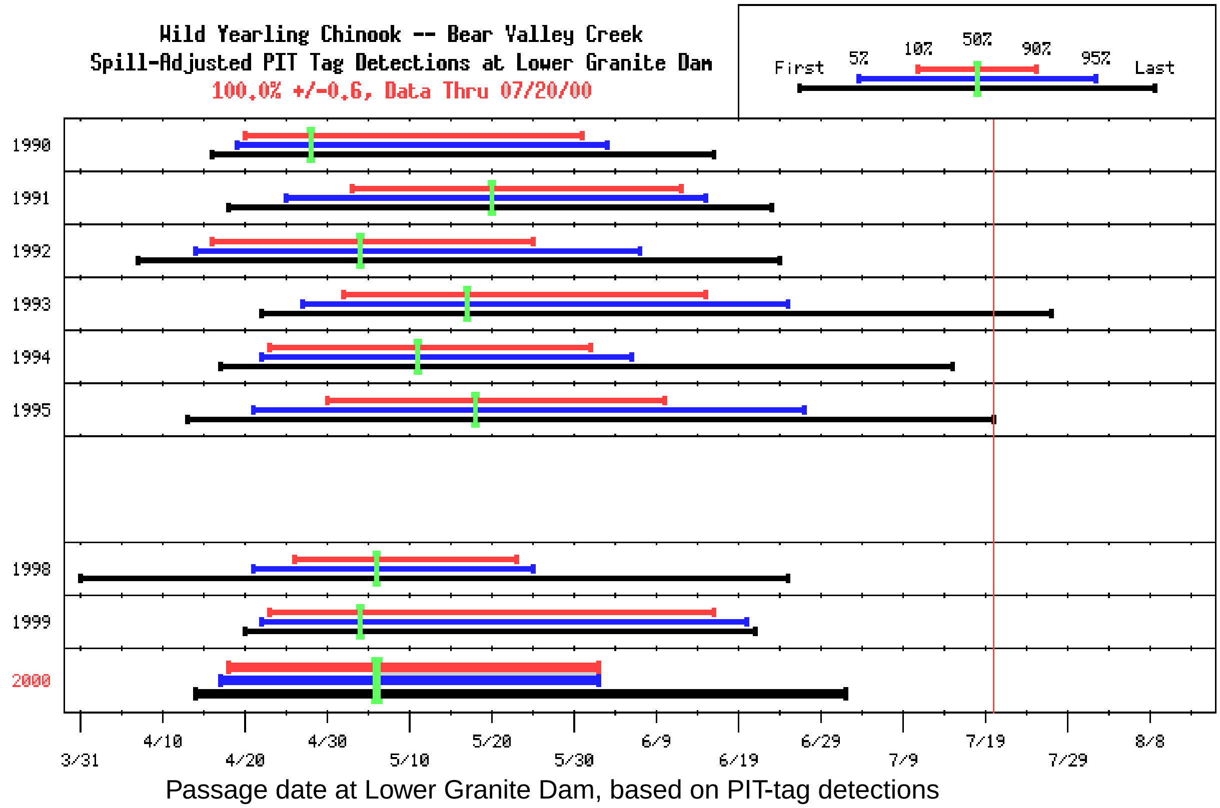


Table B1: Historical Bear Valley Creek outmigration timing characteristics.

Detection Year	Detection Dates							Middle 80% in days	Parr Released (1)	LWG PIT Counts (2)	Adjusted PIT Count (3)	Recovery % (3)/(1) x 100
	First	5%	10%	50%	90%	95%	Last					
1990	04/16	04/19	04/20	04/28	05/31	06/03	06/16	42	471	31	31.0	6.6
1991	04/18	04/25	05/03	05/20	06/12	06/15	06/23	41	352	44	44.4	12.6
1992	04/07	04/14	04/16	05/04	05/25	06/07	06/24	40	944	57	57.0	6.0
1993	04/22	04/27	05/02	05/17	06/15	06/25	07/27	45	1015	67	105.1	10.4
1994	04/17	04/22	04/23	05/11	06/01	06/06	07/15	40	856	85	115.4	13.5
1995	04/13	04/21	04/30	05/18	06/10	06/27	07/20	42	1455	74	101.7	7.0
1998	03/31	04/21	04/26	05/06	05/23	05/25	06/25	28	427	59	113.5	26.6
1999	04/20	04/22	04/23	05/04	06/16	06/20	06/21	55	820	39	92.2	11.2
2000	04/14	04/17	04/18	05/06	06/02	06/02	07/02	46	837	44	85.1	10.2

Figure B2: Historical Big Creek outmigration distribution at Lower Granite Dam.

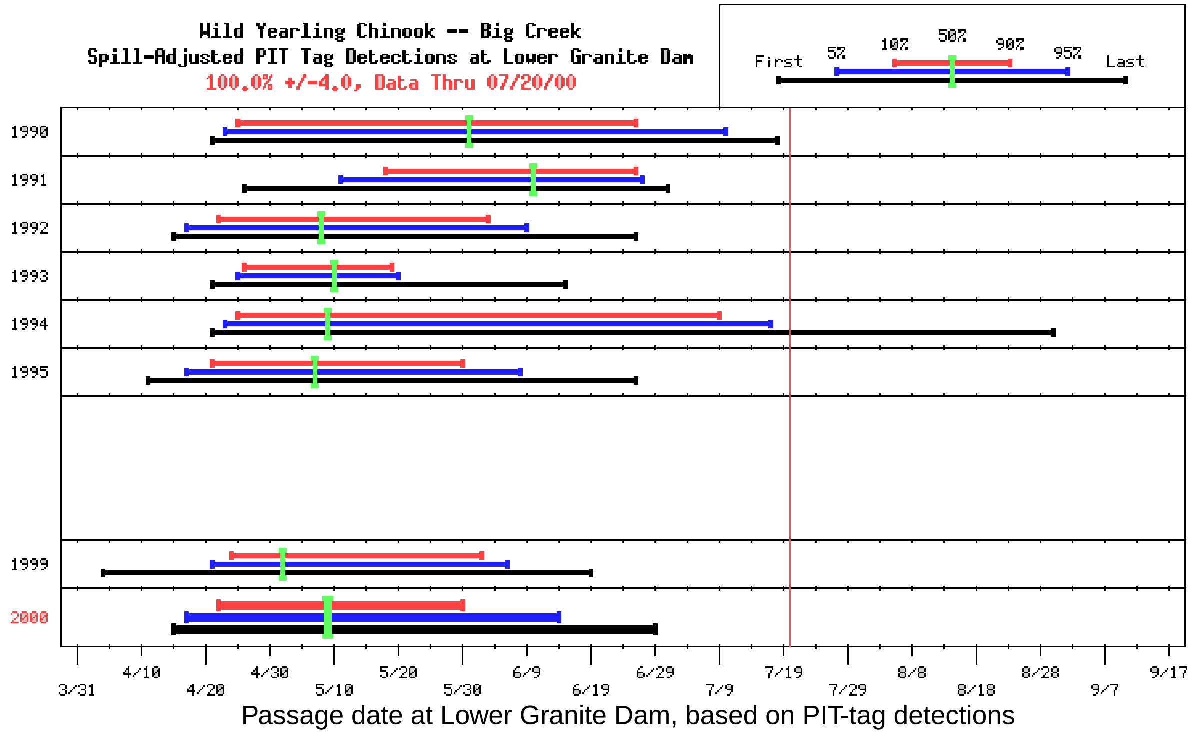
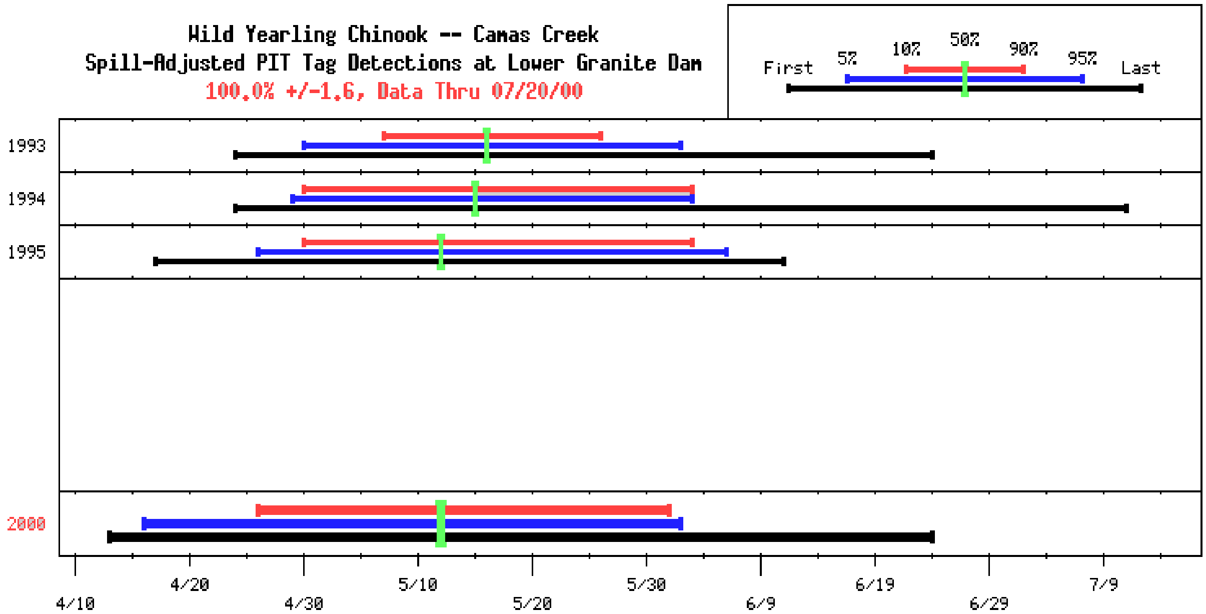


Table B2: Historical Big Creek outmigration timing characteristics.

Detection Year	Detection Dates							Middle 80% in days	Parr Released (1)	LWG PIT Counts (2)	Adjusted PIT Count (3)	Recovery % (3)/(1) x 100
	First	5%	10%	50%	90%	95%	Last					
1990	04/21	04/23	04/25	05/31	06/26	07/10	07/18	63	1134	75	75.0	6.6
1991	04/26	05/11	05/18	06/10	06/26	06/27	07/01	40	724	67	67.8	9.4
1992	04/15	04/17	04/22	05/08	06/03	06/09	06/26	43	1002	57	57.0	5.7
1993	04/21	04/25	04/26	05/10	05/19	05/20	06/15	24	733	65	84.7	11.6
1994	04/21	04/23	04/25	05/09	07/09	07/17	08/30	76	721	56	68.7	9.5
1995	04/11	04/17	04/21	05/07	05/30	06/08	06/26	40	1482	164	220.2	14.9
1999	04/04	04/21	04/24	05/02	06/02	06/06	06/19	40	1427	100	242.1	17.0
2000	04/15	04/17	04/22	05/09	05/30	06/14	06/29	39	1090	92	177.2	16.3

Figure B3: Historical Camas Creek outmigration distribution at Lower Granite Dam



Passage date at Lower Granite Dam, based on PIT-tag detections

Table B3: Historical Camas Creek outmigration timing characteristics.

Detection Year	Detection Dates							Middle 80% in days	Parr Released (1)	LWG PIT Counts (2)	Adjusted PIT Count (3)	Recovery % (3)/(1) x 100
	First	5%	10%	50%	90%	95%	Last					
1993	04/24	04/30	05/07	05/16	05/26	06/02	06/24	20	1013	66	109.2	10.8
1994	04/24	04/29	04/30	05/15	06/03	06/03	07/11	35	215	20	31.3	14.5
1995	04/17	04/26	04/30	05/12	06/03	06/06	06/11	35	1528	59	86.3	5.6
2000	04/13	04/16	04/26	05/12	06/01	06/02	06/24	37	763	53	103.7	13.6

Figure B4: Historical Cape Horn Creek outmigration distribution at Lower Granite Dam.

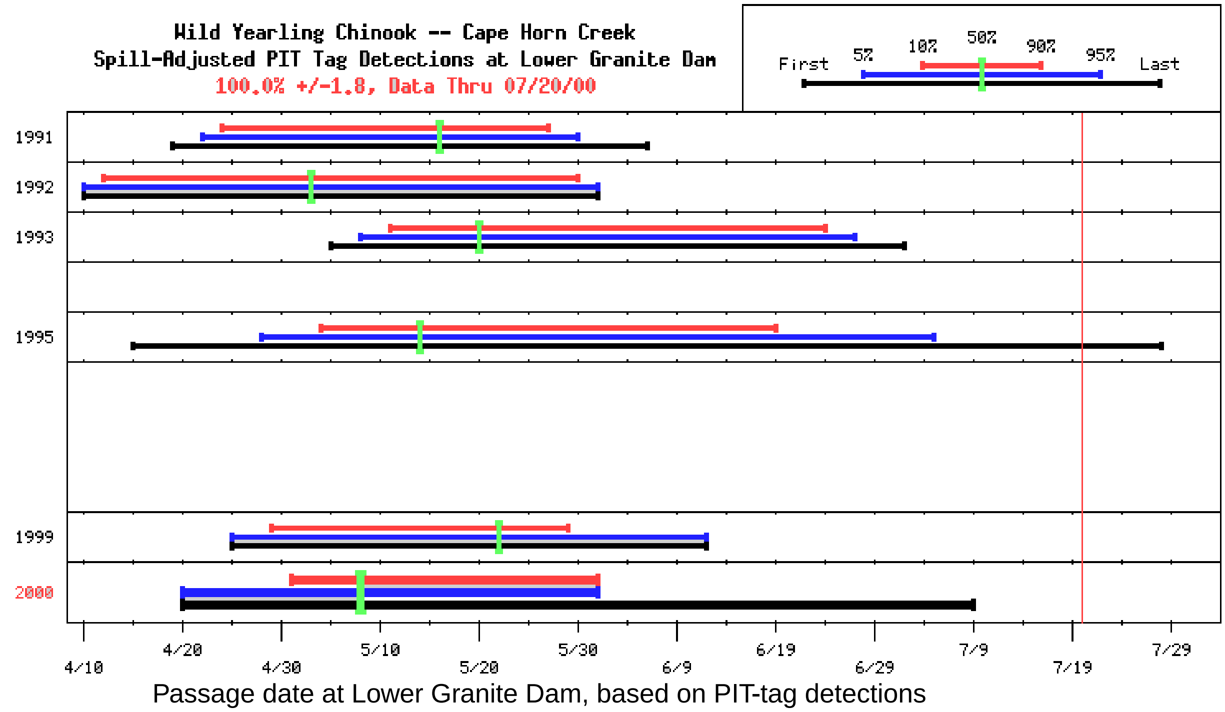
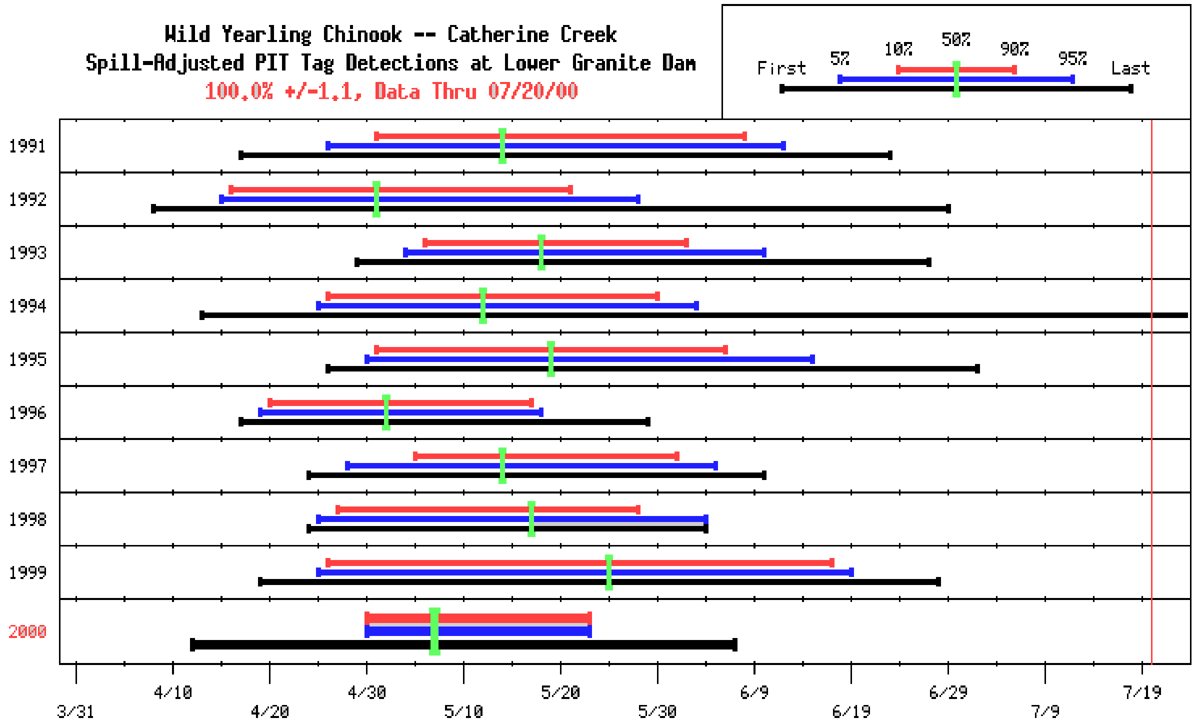


Table B4: Historical Cape Horn Creek outmigration timing characteristics.

Detection Year	Detection Dates							Middle 80% in days	Parr Released (1)	LWG PIT Counts (2)	Adjusted PIT Count (3)	Recovery % (3)/(1) x 100
	First	5%	10%	50%	90%	95%	Last					
1991	04/19	04/22	04/24	05/16	05/27	05/30	06/06	34	164	25	25.4	15.5
1992	04/10	04/10	04/12	05/03	05/30	06/01	06/01	49	209	19	19.0	9.1
1993	05/05	05/08	05/11	05/20	06/24	06/27	07/02	45	205	22	34.4	16.8
1995	04/15	04/28	05/04	05/14	06/19	07/05	07/28	47	983	58	84.6	8.6
1999	04/25	04/25	04/29	05/22	05/29	06/12	06/12	31	270	15	35.8	13.3
2000	04/20	04/20	05/01	05/08	06/01	06/01	07/09	32	423	17	32.9	7.8

Figure B5: Historical Catherine Creek outmigration distribution at Lower Granite Dam.



Passage date at Lower Granite Dam, based on PIT-tag detections

Table B5: Historical Catherine Creek outmigration timing characteristics.

Detection Year	Detection Dates							Middle 80% in days	Parr Released (1)	LWG PIT Counts (2)	Adjusted PIT Count (3)	Recovery % (3)/(1) x 100
	First	5%	10%	50%	90%	95%	Last					
1991	04/17	04/26	05/01	05/14	06/08	06/12	06/23	39	1012	77	77.8	7.7
1992	04/08	04/15	04/16	05/01	05/21	05/28	06/29	36	940	67	67.0	7.1
1993	04/29	05/04	05/06	05/18	06/02	06/10	06/27	28	1093	102	158.2	14.5
1994	04/13	04/25	04/26	05/12	05/30	06/03	07/26	35	1000	76	110.5	11.0
1995	04/26	04/30	05/01	05/19	06/06	06/15	07/02	37	1301	115	153.8	11.8
1996	04/17	04/19	04/20	05/02	05/17	05/18	05/29	28	499	40	86.2	17.3
1997	04/24	04/28	05/05	05/14	06/01	06/05	06/10	28	585	51	120.2	20.6
1998	04/24	04/25	04/27	05/17	05/28	06/04	06/04	32	500	43	91.3	18.3
1999	04/19	04/25	04/26	05/25	06/17	06/19	06/28	53	949	44	107.9	11.4
2000	04/12	04/30	04/30	05/07	05/23	05/23	06/07	24	499	30	57.2	11.5

Figure B6: Historical Elk Creek outmigration distribution at Lower Granite Dam.

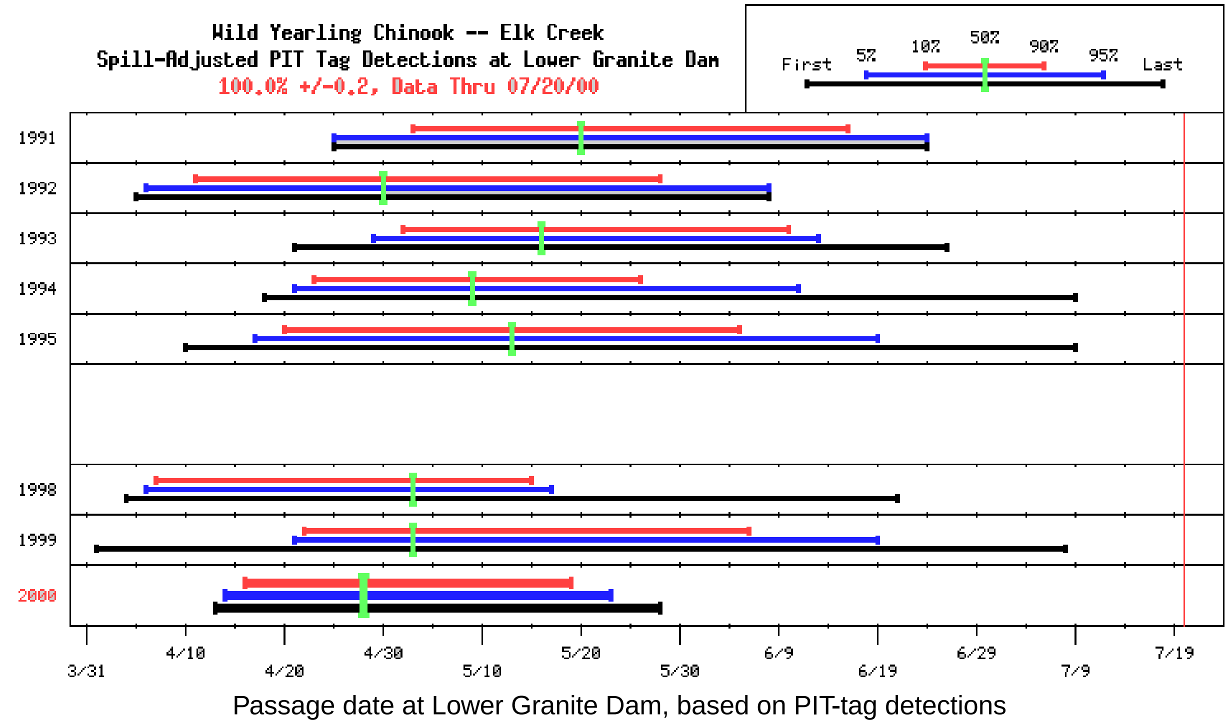


Table B6: Historical Elk Creek outmigration timing characteristics.

Detection Year	Detection Dates							Middle 80% in days	Parr Released (1)	LWG PIT Counts (2)	Adjusted PIT Count (3)	Recovery % (3)/(1) x 100
	First	5%	10%	50%	90%	95%	Last					
1991	04/17	04/26	05/01	05/14	06/08	06/12	06/23	39	1012	77	77.8	7.7
1992	04/08	04/15	04/16	05/01	05/21	05/28	06/29	36	940	67	67.0	7.1
1993	04/29	05/04	05/06	05/18	06/02	06/10	06/27	28	1093	102	158.2	14.5
1994	04/13	04/25	04/26	05/12	05/30	06/03	07/26	35	1000	76	110.5	11.0
1995	04/26	04/30	05/01	05/19	06/06	06/15	07/02	37	1301	115	153.8	11.8
1996	04/17	04/19	04/20	05/02	05/17	05/18	05/29	28	499	40	86.2	17.3
1997	04/24	04/28	05/05	05/14	06/01	06/05	06/10	28	585	51	120.2	20.6
1998	04/24	04/25	04/27	05/17	05/28	06/04	06/04	32	500	43	91.3	18.3

Figure B7: Historical Herd Creek outmigration distribution at Lower Granite Dam.

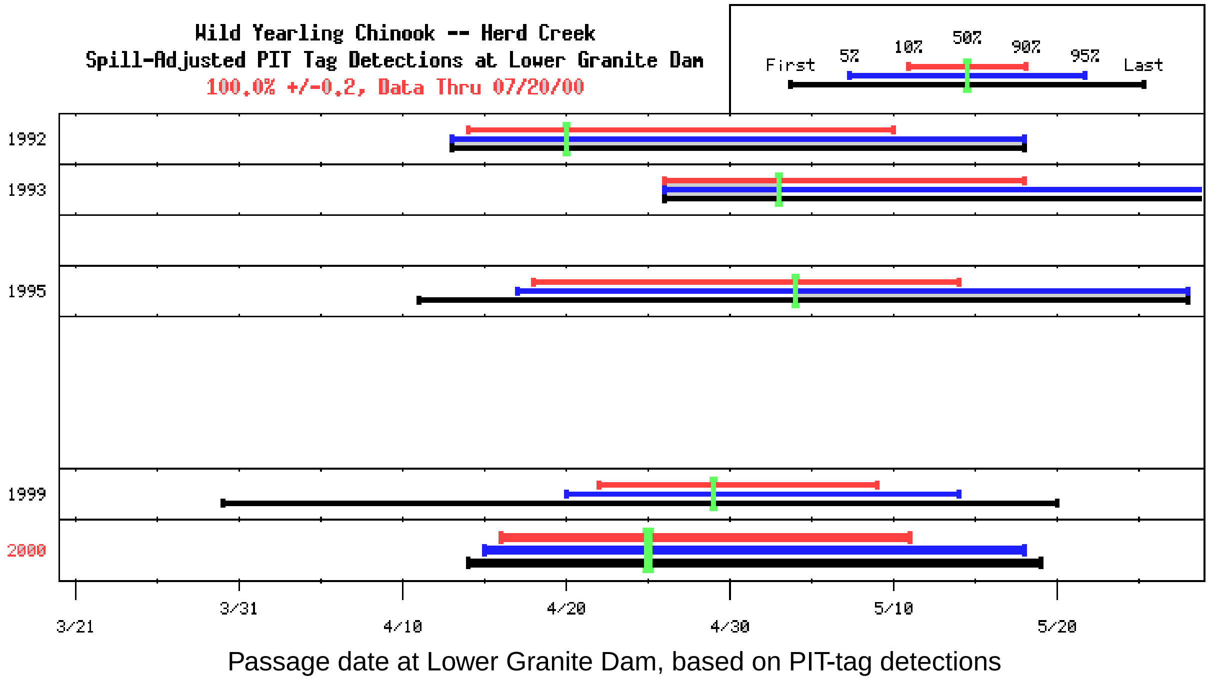
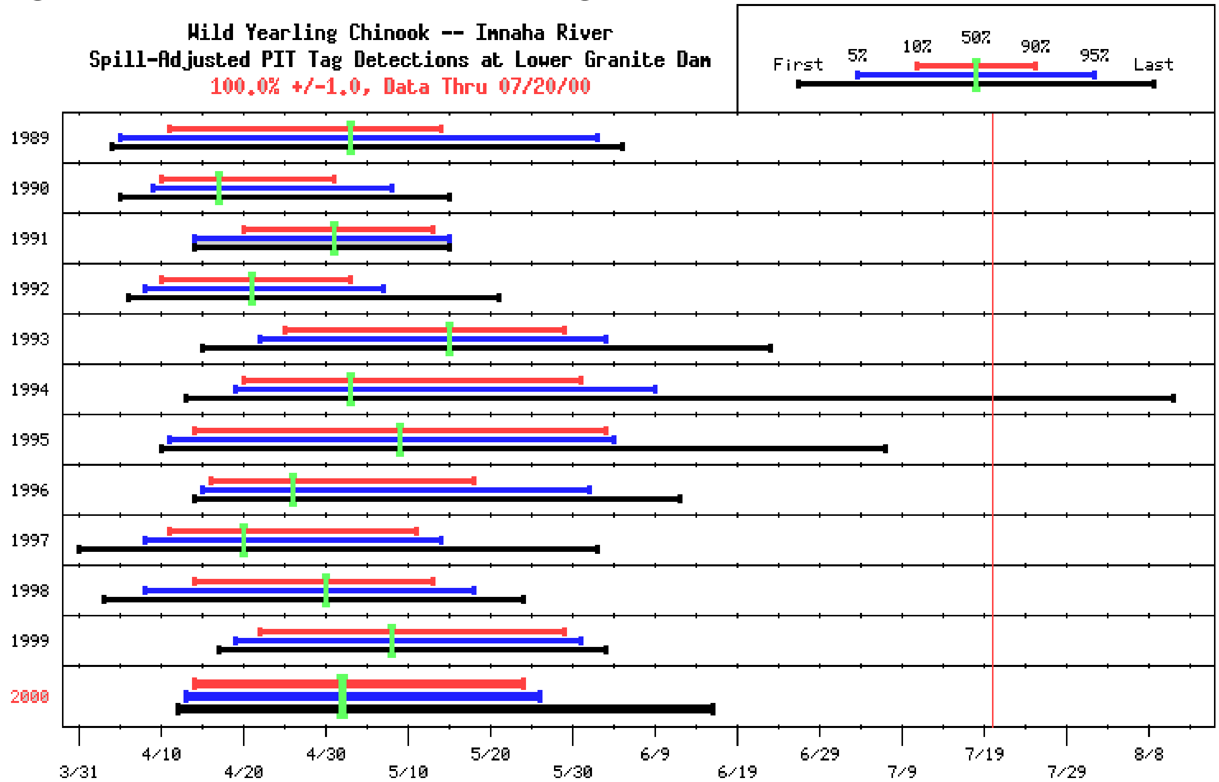


Table B7: Historical Herd Creek outmigration timing characteristics.

Detection Year	Detection Dates							Middle 80% in days	Parr Released (1)	LWG PIT Counts (2)	Adjusted PIT Count (3)	Recovery % (3)/(1) x 100
	First	5%	10%	50%	90%	95%	Last					
1992	04/13	04/13	04/14	04/20	05/10	05/18	05/18	27	310	17	17.0	5.5
1993	04/26	04/26	04/26	05/03	05/18	05/31	05/31	23	224	16	19.5	8.7
1995	04/11	04/17	04/18	05/04	05/14	05/28	05/28	27	534	36	46.2	8.7
1999	03/30	04/20	04/22	04/29	05/09	05/14	05/20	18	959	58	136.2	14.2
2000	04/14	04/15	04/16	04/25	05/11	05/18	05/19	26	315	23	44.3	14.1

Figure B8: Historical Imnaha River outmigration distribution at Lower Granite Dam.



Passage date at Lower Granite Dam, based on PIT-tag detections

Table B8: Historical Imnaha River outmigration timing characteristics.

Detection Year	Detection Dates							Middle 80% in days	Parr Released (1)	LWG PIT Counts (2)	Adjusted PIT Count (3)	Recovery % (3)/(1) x 100
	First	5%	10%	50%	90%	95%	Last					
1989	04/04	04/05	04/11	05/03	05/14	06/02	06/05	34	588	36	36.0	6.1
1990	04/05	04/09	04/10	04/17	05/01	05/08	05/15	22	897	69	69.0	7.7
1991	04/14	04/14	04/20	05/01	05/13	05/15	05/15	24	327	18	18.0	5.5
1992	04/06	04/08	04/10	04/21	05/03	05/07	05/21	24	758	73	73.0	9.6
1993	04/15	04/22	04/25	05/15	05/29	06/03	06/23	35	1003	63	88.3	8.8
1994	04/13	04/19	04/20	05/03	05/31	06/09	08/11	42	1167	91	104.2	8.9
1995	04/10	04/11	04/14	05/09	06/03	06/04	07/07	51	996	40	50.9	5.1
1996	04/14	04/15	04/16	04/26	05/18	06/01	06/12	33	997	97	233.5	23.4
1997	03/31	04/08	04/11	04/20	05/11	05/14	06/02	31	1017	98	191.1	18.8
1998	04/03	04/08	04/14	04/30	05/13	05/18	05/24	30	1010	159	283.5	28.1
1999	04/17	04/19	04/22	05/08	05/29	05/31	06/03	38	1009	41	97.7	9.7
2000	04/12	04/13	04/14	05/02	05/24	05/26	06/16	41	982	63	119.5	12.2

Figure B9: Historical Johnson Creek outmigration distribution at Lower Granite Dam.

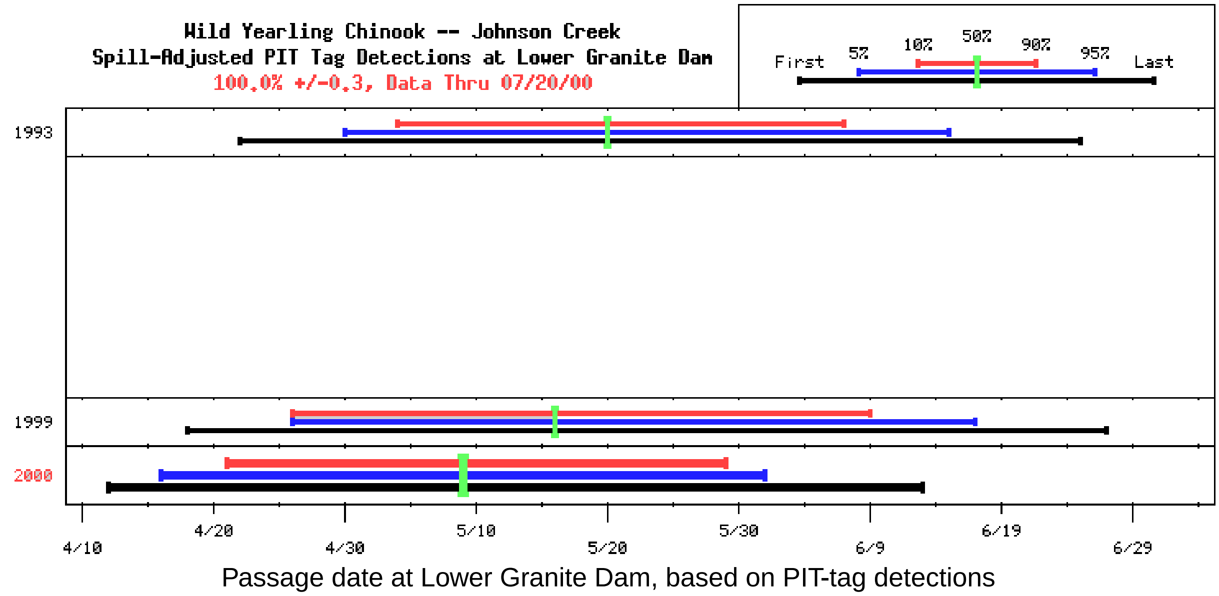


Table B9: Historical Johnson Creek outmigration timing characteristics.

Detection Year	Detection Dates							Middle 80% in days	Parr Released (1)	LWG PIT Counts (2)	Adjusted PIT Count (3)	Recovery % (3)/(1) x 100
	First	5%	10%	50%	90%	95%	Last					
1993	04/22	04/30	05/04	05/20	06/07	06/15	06/25	35	634	53	81.0	12.8
1999	04/18	04/26	04/26	05/16	06/09	06/17	06/27	45	1177	58	141.9	12.1
2000	04/12	04/16	04/21	05/09	05/29	06/01	06/13	39	913	49	94.5	10.3

Figure B10: Historical Lake Creek outmigration distribution at Lower Granite Dam.

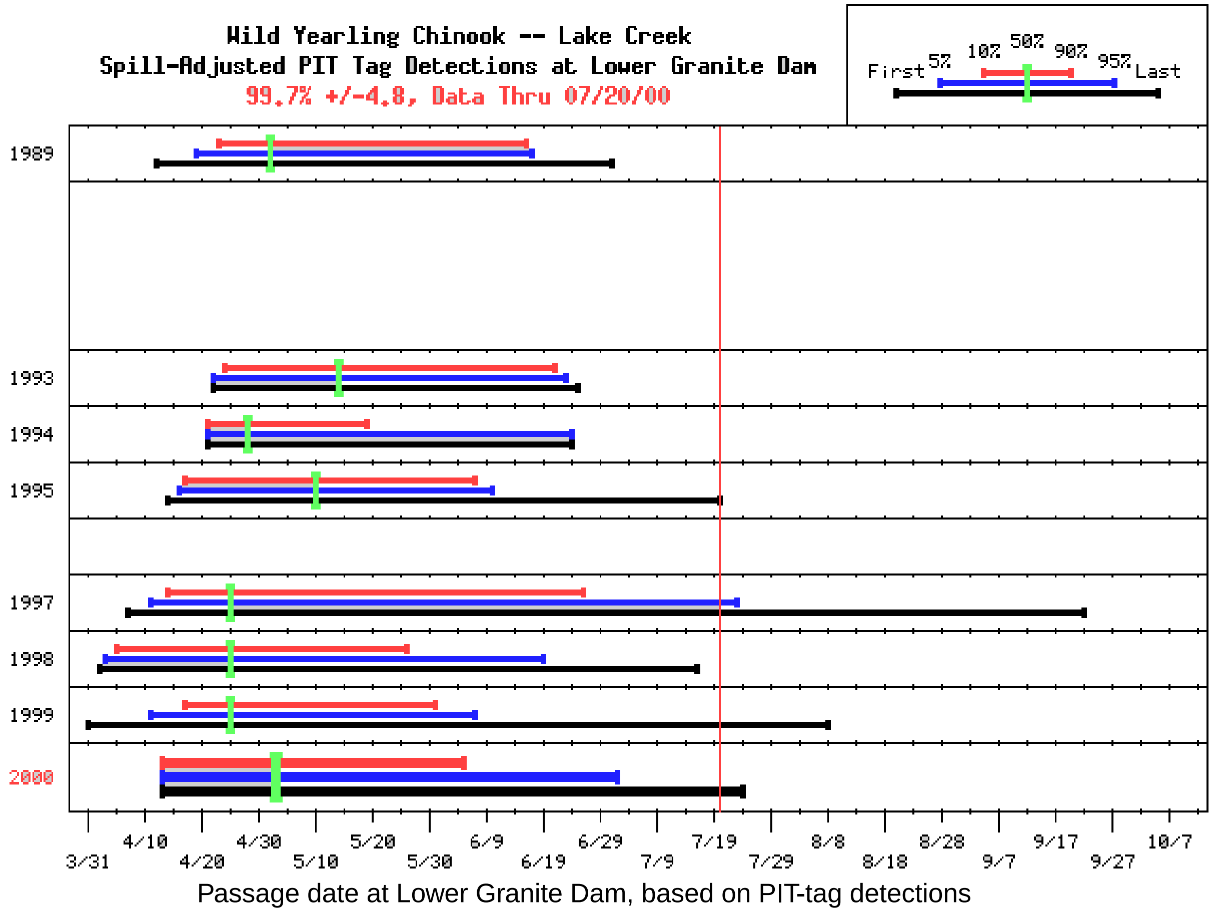


Table B10: Historical Lake Creek outmigration timing characteristics.

Detection Year	Detection Dates							Middle 80% in days	Parr Released (1)	LWG PIT Counts (2)	Adjusted PIT Count (3)	Recovery % (3)/(1) x 100
	First	5%	10%	50%	90%	95%	Last					
1989	04/12	04/19	04/23	05/02	06/16	06/17	07/01	55	657	51	51.0	7.8
1993	04/22	04/22	04/24	05/14	06/21	06/23	06/25	59	255	27	31.1	12.2
1994	04/21	04/21	04/21	04/28	05/19	06/24	06/24	29	252	17	19.8	7.9
1995	04/14	04/16	04/17	05/10	06/07	06/10	07/20	52	405	25	33.2	8.2
1997	04/07	04/11	04/14	04/25	06/26	07/23	09/22	74	400	22	41.8	10.4
1998	04/02	04/03	04/05	04/25	05/26	06/19	07/16	52	418	48	80.3	19.2
1999	03/31	04/11	04/17	04/25	05/31	06/07	08/08	45	5267	306	705.0	13.4
2000	04/13	04/13	04/13	05/03	06/05	07/02	07/24	54	603	30	54.5	9.0

Figure B11: Historical Loon Creek outmigration distribution at Lower Granite Dam.

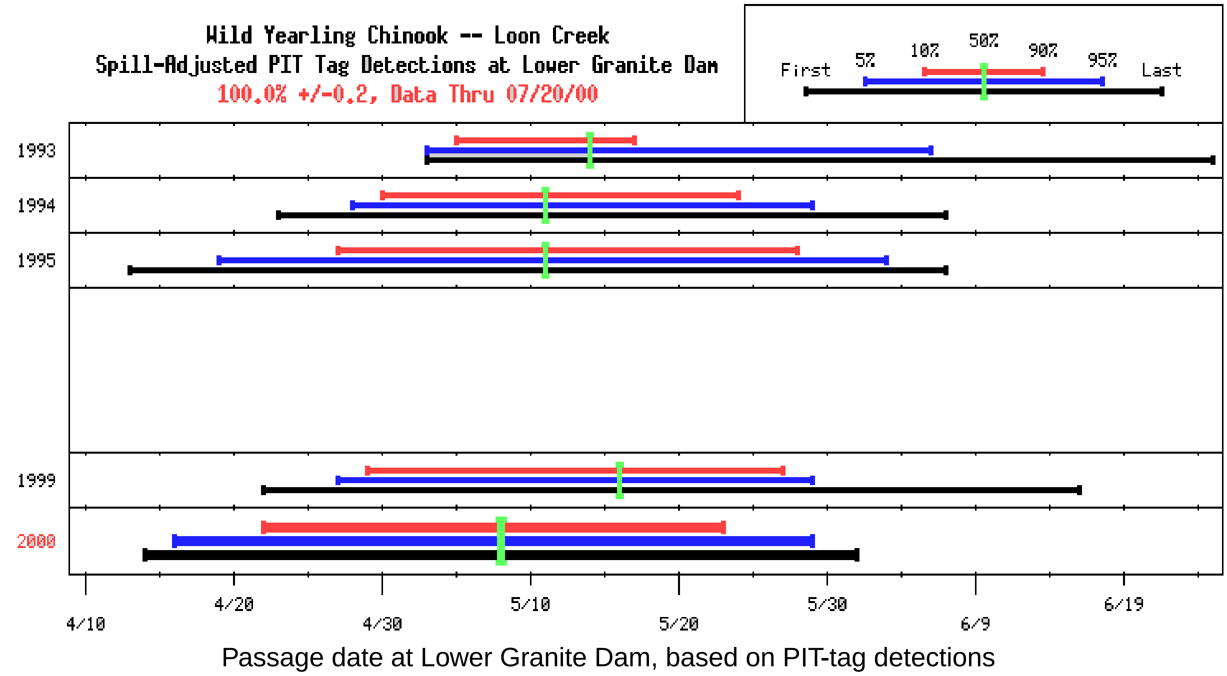


Table B11: Historical Loon Creek outmigration timing characteristics.

Detection Year	Detection Dates							Middle 80% in days	Parr Released (1)	LWG PIT Counts (2)	Adjusted PIT Count (3)	Recovery % (3)/(1) x 100
	First	5%	10%	50%	90%	95%	Last					
1993	05/03	05/03	05/05	05/14	05/17	06/06	06/25	13	261	24	35.3	13.5
1994	04/23	04/28	04/30	05/11	05/24	05/29	06/07	25	396	37	50.8	12.8
1995	04/13	04/19	04/27	05/11	05/28	06/03	06/07	32	964	83	117.8	12.2
1999	04/22	04/27	04/29	05/16	05/27	05/29	06/16	29	1029	71	173.4	16.9
2000	04/14	04/16	04/22	05/08	05/23	05/29	06/01	32	719	47	90.0	12.5

Figure B12: Historical Lostine River outmigration distribution at Lower Granite Dam.

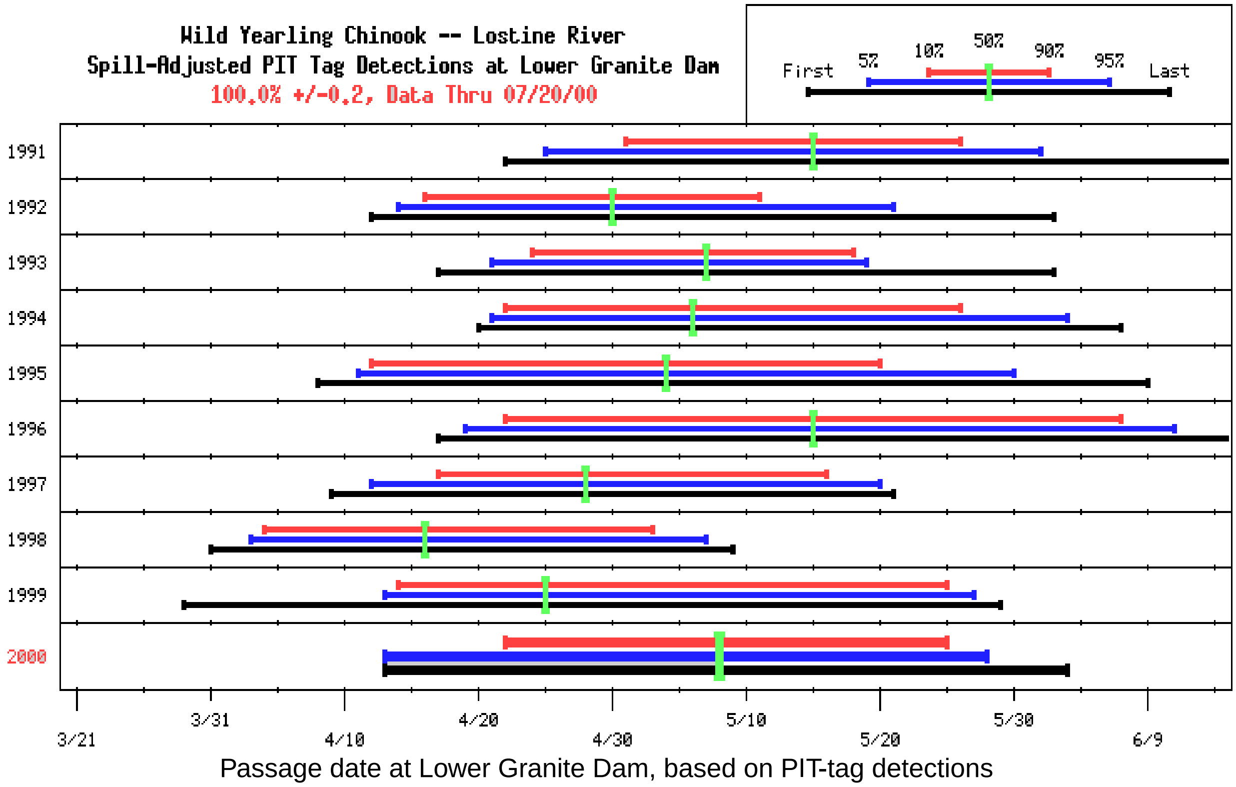
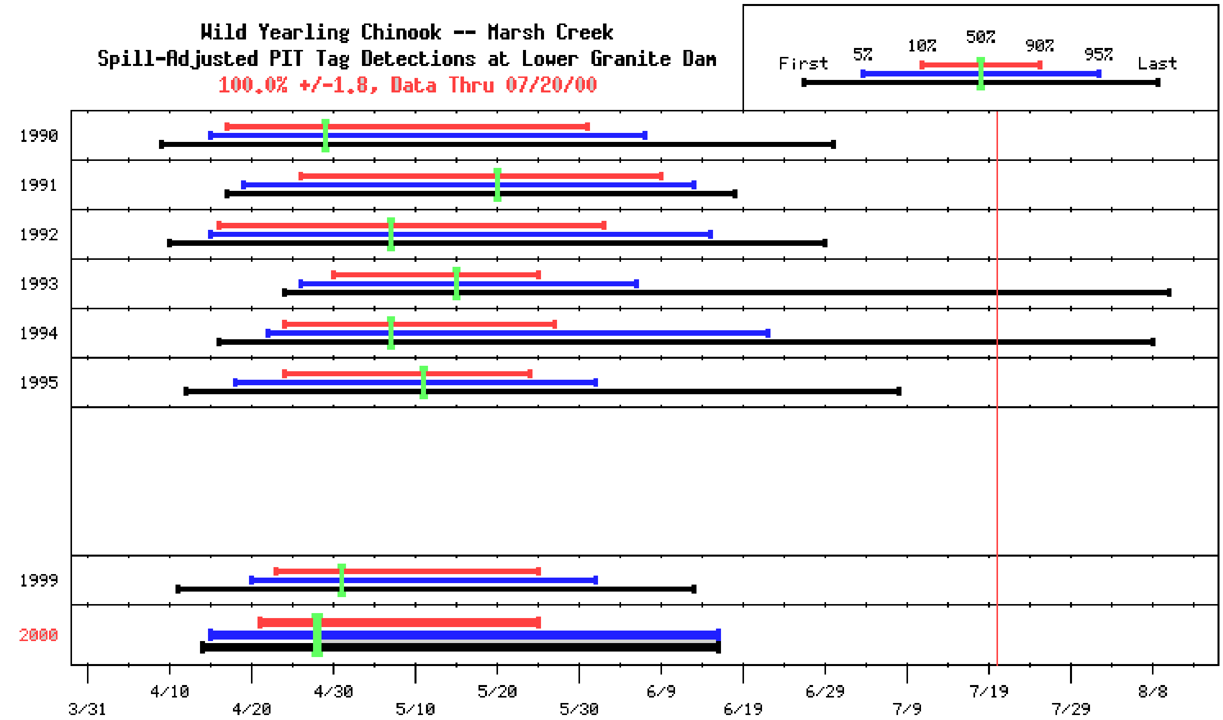


Table B12: Historical Lostine River outmigration timing characteristics.

Detection Year	Detection Dates							Middle 80% in days	Parr Released (1)	LWG PIT Counts (2)	Adjusted PIT Count (3)	Recovery % (3)/(1) x 100
	First	5%	10%	50%	90%	95%	Last					
1991	04/22	04/25	05/01	05/15	05/26	06/01	06/18	26	549	51	51.8	9.4
1992	04/12	04/14	04/16	04/30	05/11	05/21	06/02	26	1107	92	92.0	8.3
1993	04/17	04/21	04/24	05/07	05/18	05/19	06/02	25	999	123	156.1	15.6
1994	04/20	04/21	04/22	05/06	05/26	06/03	06/07	35	725	71	87.4	12.1
1995	04/08	04/11	04/12	05/04	05/20	05/30	06/09	39	1002	112	142.0	14.2
1996	04/17	04/19	04/22	05/15	06/07	06/11	06/19	47	978	81	188.2	19.2
1997	04/09	04/12	04/17	04/28	05/16	05/20	05/21	30	527	43	93.0	17.6
1998	03/31	04/03	04/04	04/16	05/03	05/07	05/09	30	236	46	70.5	29.9
1999	03/29	04/13	04/14	04/25	05/25	05/27	05/29	42	823	44	106.6	13.0
2000	04/13	04/13	04/22	05/08	05/25	05/28	06/03	34	509	36	68.8	13.5

Figure B13: Historical Marsh Creek outmigration distribution at Lower Granite Dam.



Passage date at Lower Granite Dam, based on PIT-tag detections

Table B13: Historical Marsh Creek outmigration timing characteristics.

Detection Year	Detection Dates							Middle 80% in days	Parr Released (1)	LWG PIT Counts (2)	Adjusted PIT Count (3)	Recovery % (3)/(1) x 100
	First	5%	10%	50%	90%	95%	Last					
1990	04/09	04/15	04/17	04/29	05/31	06/07	06/30	45	2496	179	179.0	7.2
1991	04/17	04/19	04/26	05/20	06/09	06/13	06/18	45	861	59	59.0	6.9
1992	04/10	04/15	04/16	05/07	06/02	06/15	06/29	48	696	46	46.0	6.6
1993	04/24	04/26	04/30	05/15	05/25	06/06	08/10	26	1000	82	126.5	12.6
1994	04/16	04/22	04/24	05/07	05/27	06/22	08/08	34	944	75	90.8	9.6
1995	04/12	04/18	04/24	05/11	05/24	06/01	07/08	31	1095	68	94.8	8.7
1999	04/11	04/20	04/23	05/01	05/25	06/01	06/13	33	769	58	139.2	18.1
2000	04/14	04/15	04/21	04/28	05/25	06/16	06/16	35	554	23	46.6	8.4

Figure B14: Historical Minam River outmigration distribution at Lower Granite Dam.

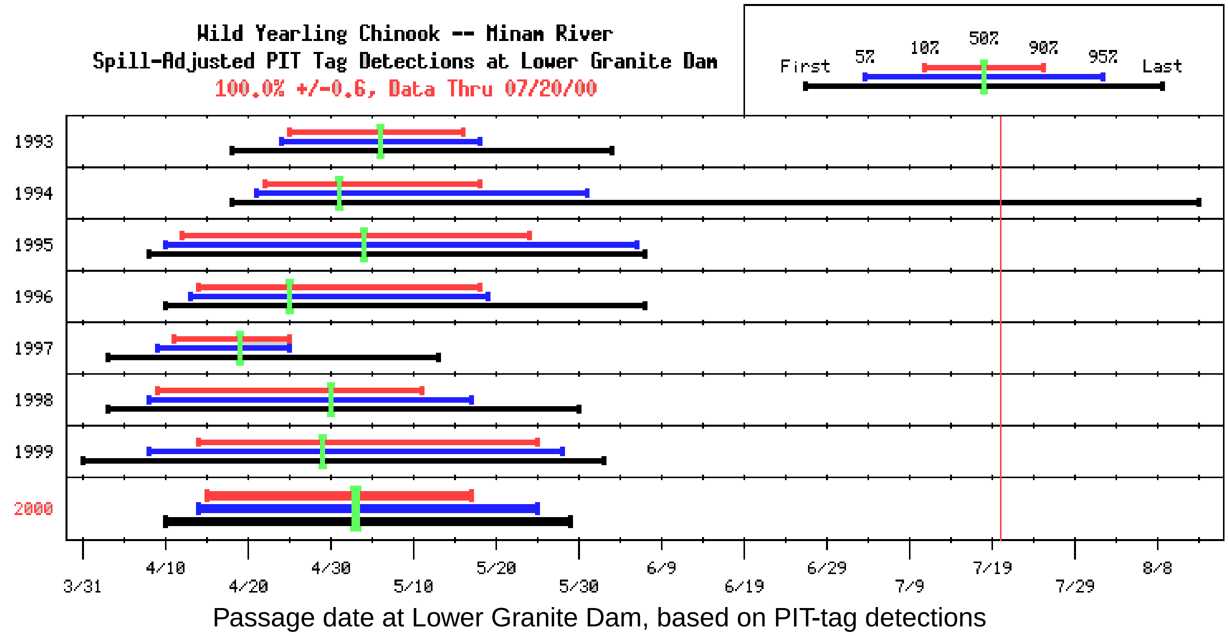


Table B14: Historical Minam River outmigration timing characteristics.

Detection Year	Detection Dates							Middle 80% in days	Parr Released (1)	LWG PIT Counts (2)	Adjusted PIT Count (3)	Recovery % (3)/(1) x 100
	First	5%	10%	50%	90%	95%	Last					
1993	04/18	04/24	04/25	05/06	05/16	05/18	06/03	22	1000	105	125.5	12.5
1994	04/18	04/21	04/22	05/01	05/18	05/31	08/13	27	997	112	133.3	13.4
1995	04/08	04/10	04/12	05/04	05/24	06/06	06/07	43	996	70	89.3	9.0
1996	04/10	04/13	04/14	04/25	05/18	05/19	06/07	35	998	68	164.9	16.5
1997	04/03	04/09	04/11	04/19	04/25	04/25	05/13	15	589	49	92.4	15.7
1998	04/03	04/08	04/09	04/30	05/11	05/17	05/30	33	998	123	221.8	22.2
1999	03/31	04/08	04/14	04/29	05/25	05/28	06/02	42	1006	51	120.4	12.0
2000	04/10	04/14	04/15	05/03	05/17	05/25	05/29	33	998	74	142.1	14.2

Figure B15: Historical Salmon River, EF outmigration distribution at Lower Granite Dam.

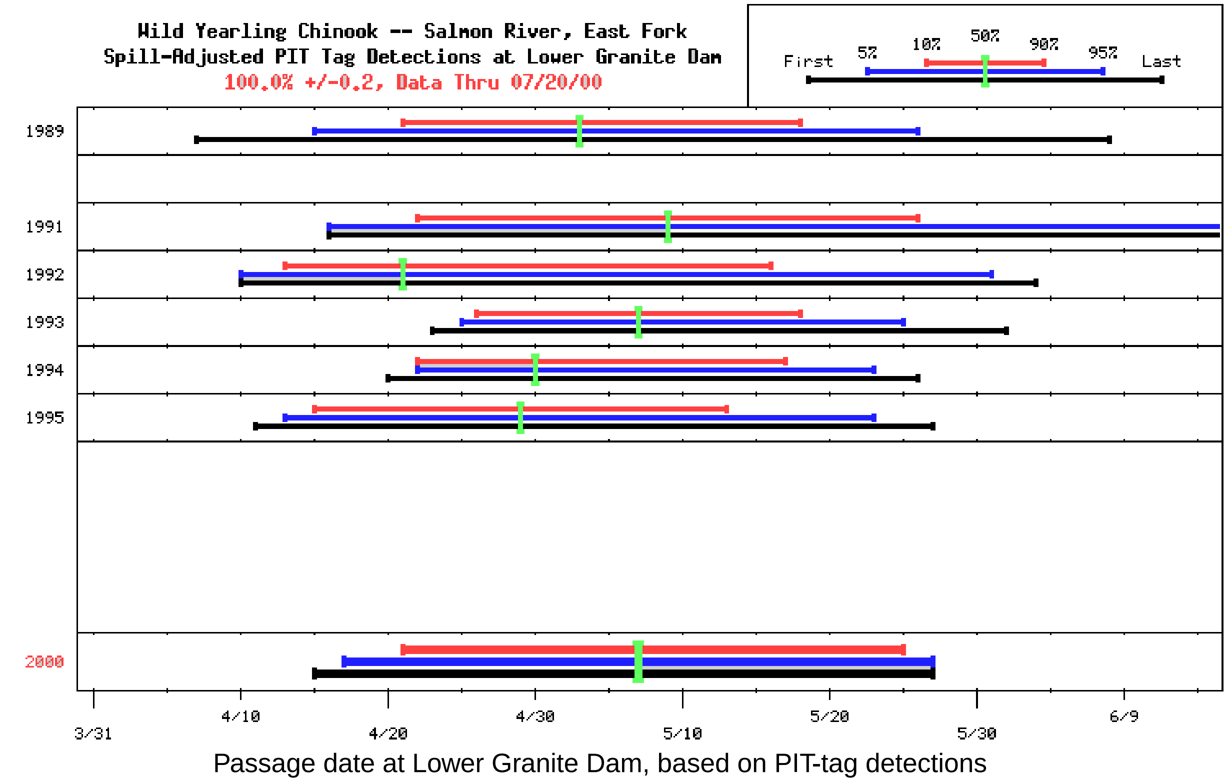
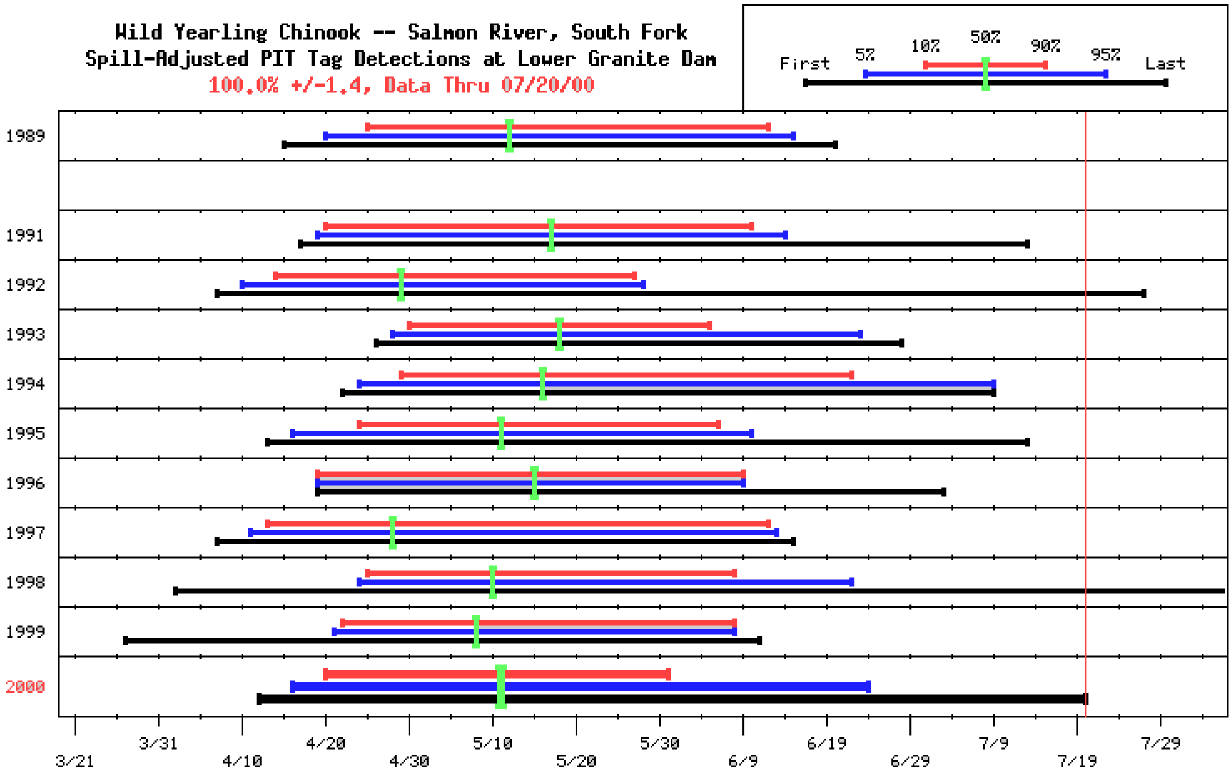


Table B15: Historical Salmon River, EF outmigration timing characteristics.

Detection Year	Detection Dates							Middle 80% in days	Parr Released (1)	LWG PIT Counts (2)	Adjusted PIT Count (3)	Recovery % (3)/(1) x 100
	First	5%	10%	50%	90%	95%	Last					
1989	04/07	04/15	04/21	05/03	05/18	05/26	06/08	28	611	50	50.0	8.2
1991	04/16	04/16	04/22	05/09	05/26	06/20	06/20	35	532	18	18.0	3.4
1992	04/10	04/10	04/13	04/21	05/16	05/31	06/03	34	669	33	33.0	4.9
1993	04/23	04/25	04/26	05/07	05/18	05/25	06/01	23	749	37	45.2	6.0
1994	04/20	04/22	04/22	04/30	05/17	05/23	05/26	26	883	45	51.6	5.8
1995	04/11	04/13	04/15	04/29	05/13	05/23	05/27	29	986	69	81.6	8.3
2000	04/15	04/17	04/21	05/07	05/25	05/27	05/27	35	674	35	66.2	9.8

Figure B16: Historical Salmon River, SF outmigration distribution at Lower Granite Dam.

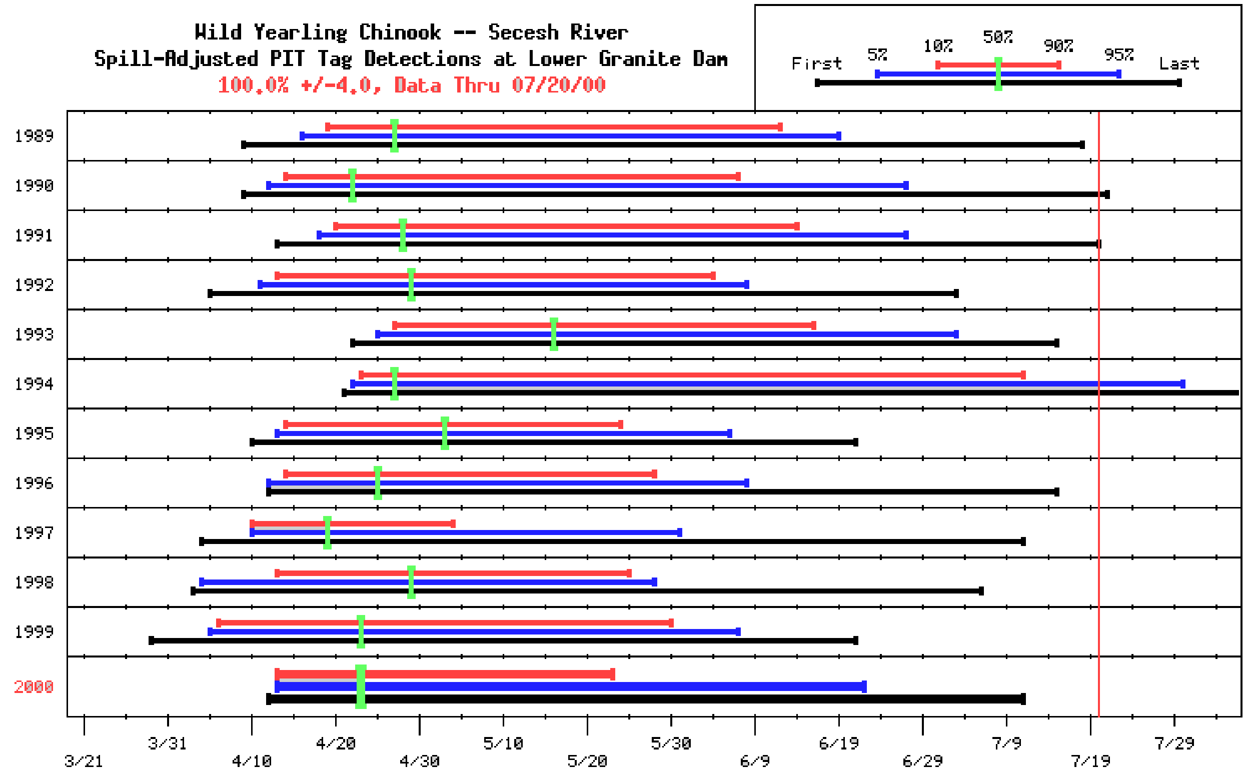


Passage date at Lower Granite Dam, based on PIT-tag detections

Table B16: Historical Salmon River, SF outmigration timing characteristics.

Detection Year	Detection Dates							Middle 80% in days	Parr Released (1)	LWG PIT Counts (2)	Adjusted PIT Count (3)	Recovery % (3)/(1) x 100
	First	5%	10%	50%	90%	95%	Last					
1989	04/15	04/20	04/25	05/12	06/12	06/15	06/20	49	2178	84	84.0	3.9
1991	04/17	04/19	04/20	05/17	06/10	06/14	07/13	52	986	98	98.8	10.0
1992	04/07	04/10	04/14	04/29	05/27	05/28	07/27	44	1027	81	81.0	7.9
1993	04/26	04/28	04/30	05/18	06/05	06/23	06/28	37	723	48	79.4	11.0
1994	04/22	04/24	04/29	05/16	06/22	07/09	07/09	55	803	41	58.1	7.2
1995	04/13	04/16	04/24	05/11	06/06	06/10	07/13	44	1571	78	105.2	6.7
1996	04/19	04/19	04/19	05/15	06/09	06/09	07/03	52	700	16	37.2	5.3
1997	04/07	04/11	04/13	04/28	06/12	06/13	06/15	61	700	36	78.9	11.3
1998	04/02	04/24	04/25	05/10	06/08	06/22	08/07	45	1007	83	155.5	15.4
1999	03/27	04/21	04/22	05/08	06/08	06/08	06/11	48	998	38	87.6	8.8
2000	04/12	04/16	04/20	05/11	05/31	06/24	07/20	42	1010	39	72.0	7.1

Figure B17: Historical Secesh River outmigration distribution at Lower Granite Dam.



Passage date at Lower Granite Dam, based on PIT-tag detections

Table B17: Historical Secesh River outmigration timing characteristics.

Detection Year	Detection Dates							Middle 80% in days	Parr Released (1)	LWG PIT Counts (2)	Adjusted PIT Count (3)	Recovery % (3)/(1) x 100
	First	5%	10%	50%	90%	95%	Last					
1989	04/09	04/16	04/19	04/27	06/12	06/19	07/18	55	1507	142	142.0	9.4
1990	04/09	04/12	04/14	04/22	06/07	06/27	07/21	55	1545	108	108.0	7.0
1991	04/13	04/18	04/20	04/28	06/14	06/27	07/20	56	1016	71	72.3	7.1
1992	04/05	04/11	04/13	04/29	06/04	06/08	07/03	53	1012	40	40.0	4.0
1993	04/22	04/25	04/27	05/16	06/16	07/03	07/15	51	327	30	37.0	11.3
1994	04/21	04/22	04/23	04/27	07/11	07/30	08/07	80	422	32	33.0	7.8
1995	04/10	04/13	04/14	05/03	05/24	06/06	06/21	41	1213	74	90.6	7.5
1996	04/12	04/12	04/14	04/25	05/28	06/08	07/15	45	571	26	70.0	12.3
1997	04/04	04/10	04/10	04/19	05/04	05/31	07/11	25	260	34	62.7	24.1
1998	04/03	04/04	04/13	04/29	05/25	05/28	07/06	43	588	74	126.1	21.4
1999	03/29	04/05	04/06	04/23	05/30	06/07	06/21	55	936	36	80.4	8.6
2000	04/12	04/13	04/13	04/23	05/23	06/22	07/11	41	907	40	74.2	8.2

Figure B18: Historical Sulfur Creek outmigration distribution at Lower Granite Dam.

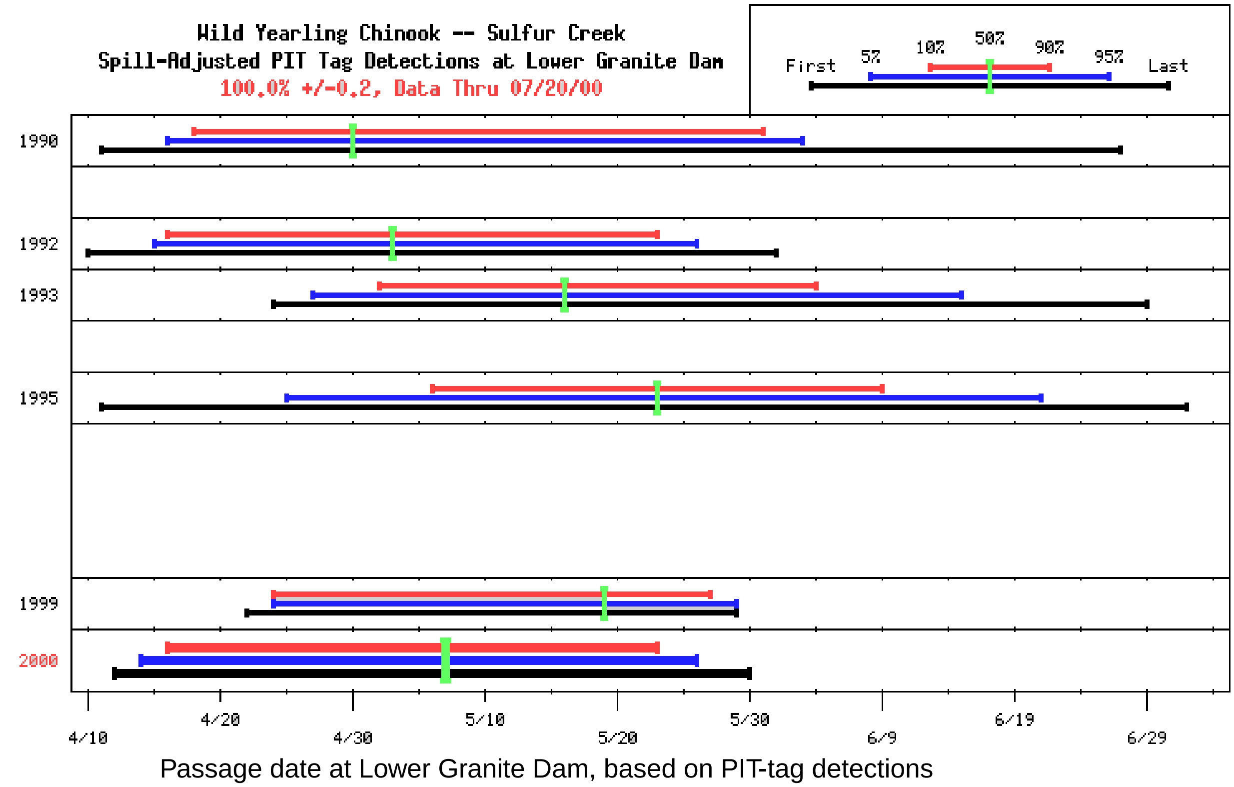


Table B18: Historical Sulfur Creek outmigration timing characteristics.

Detection Year	Detection Dates							Middle 80% in days	Parr Released (1)	LWG PIT Counts (2)	Adjusted PIT Count (3)	Recovery % (3)/(1) x 100
	First	5%	10%	50%	90%	95%	Last					
1990	04/11	04/16	04/18	04/30	05/31	06/03	06/27	44	1043	83	83.0	8.0
1992	04/10	04/15	04/16	05/03	05/23	05/26	06/01	38	210	24	24.0	11.4
1993	04/24	04/27	05/02	05/16	06/04	06/15	06/29	34	712	28	41.6	5.8
1995	04/11	04/25	05/06	05/23	06/09	06/21	07/02	35	728	56	80.2	11.0
1999	04/22	04/24	04/24	05/19	05/27	05/29	05/29	34	443	17	42.1	9.5
2000	04/12	04/14	04/16	05/07	05/23	05/26	05/30	38	838	52	99.0	11.8

Figure B19: Historical Valley Creek outmigration distribution at Lower Granite Dam.

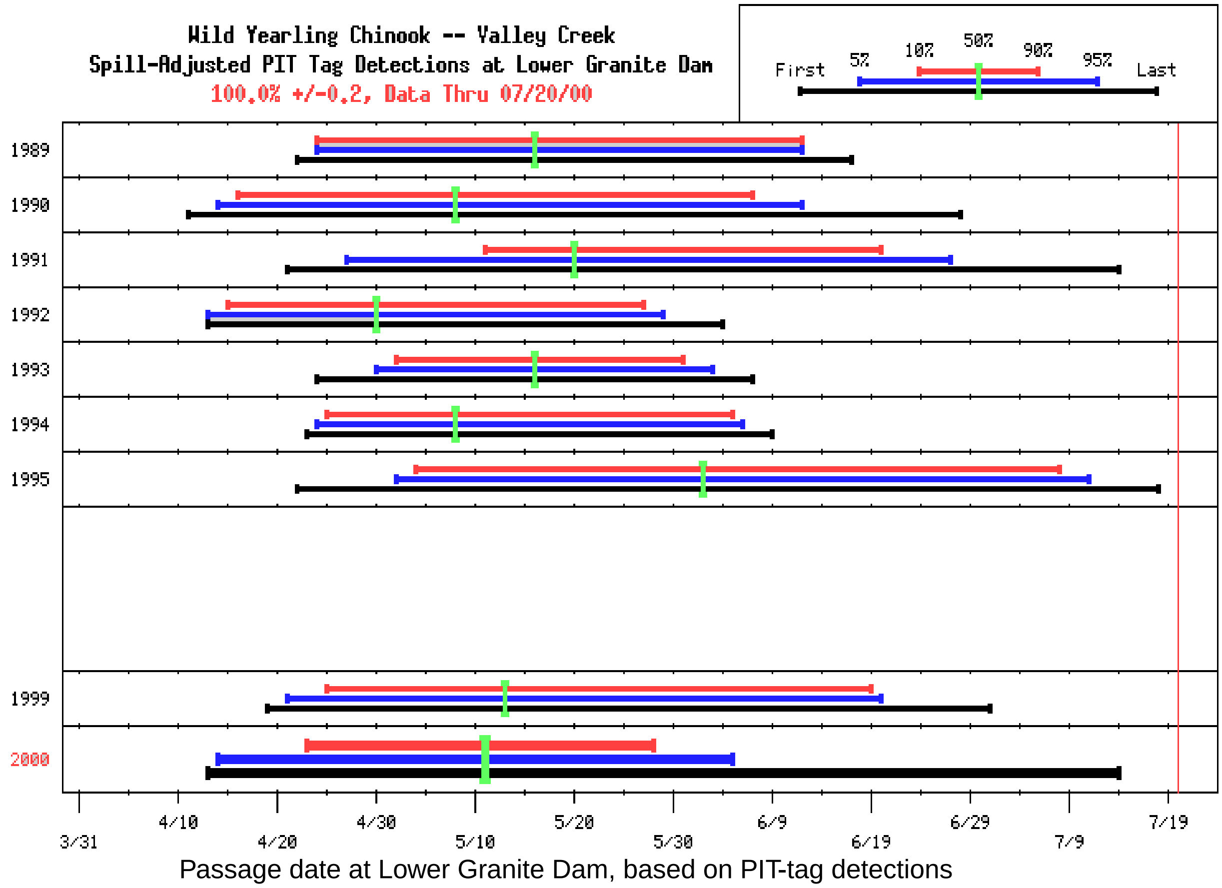


Table B19: Historical Valley Creek outmigration timing characteristics.

Detection Year	Detection Dates							Middle 80% in days	Parr Released (1)	LWG PIT Counts (2)	Adjusted PIT Count (3)	Recovery % (3)/(1) x 100
	First	5%	10%	50%	90%	95%	Last					
1989	04/22	04/24	04/24	05/16	06/12	06/12	06/17	50	1241	43	43.0	3.5
1990	04/11	04/14	04/16	05/08	06/07	06/12	06/28	53	2496	76	76.0	3.0
1991	04/21	04/27	05/11	05/20	06/20	06/27	07/14	41	1024	41	41.0	4.0
1992	04/13	04/13	04/15	04/30	05/27	05/29	06/04	43	969	34	34.0	3.5
1993	04/24	04/30	05/02	05/16	05/31	06/03	06/07	30	1026	32	51.2	5.0
1994	04/23	04/24	04/25	05/08	06/05	06/06	06/09	42	848	45	61.8	7.3
1995	04/22	05/02	05/04	06/02	07/08	07/11	07/18	66	1551	50	64.0	4.1
1999	04/19	04/21	04/25	05/13	06/19	06/20	07/01	56	1001	50	118.3	11.8
2000	04/13	04/14	04/23	05/11	05/28	06/05	07/14	36	1009	51	95.7	9.5

Figure B20: Historical All-Wild PIT-tagged Yearling Chinook Salmon outmigration distribution at Lower Granite Dam.

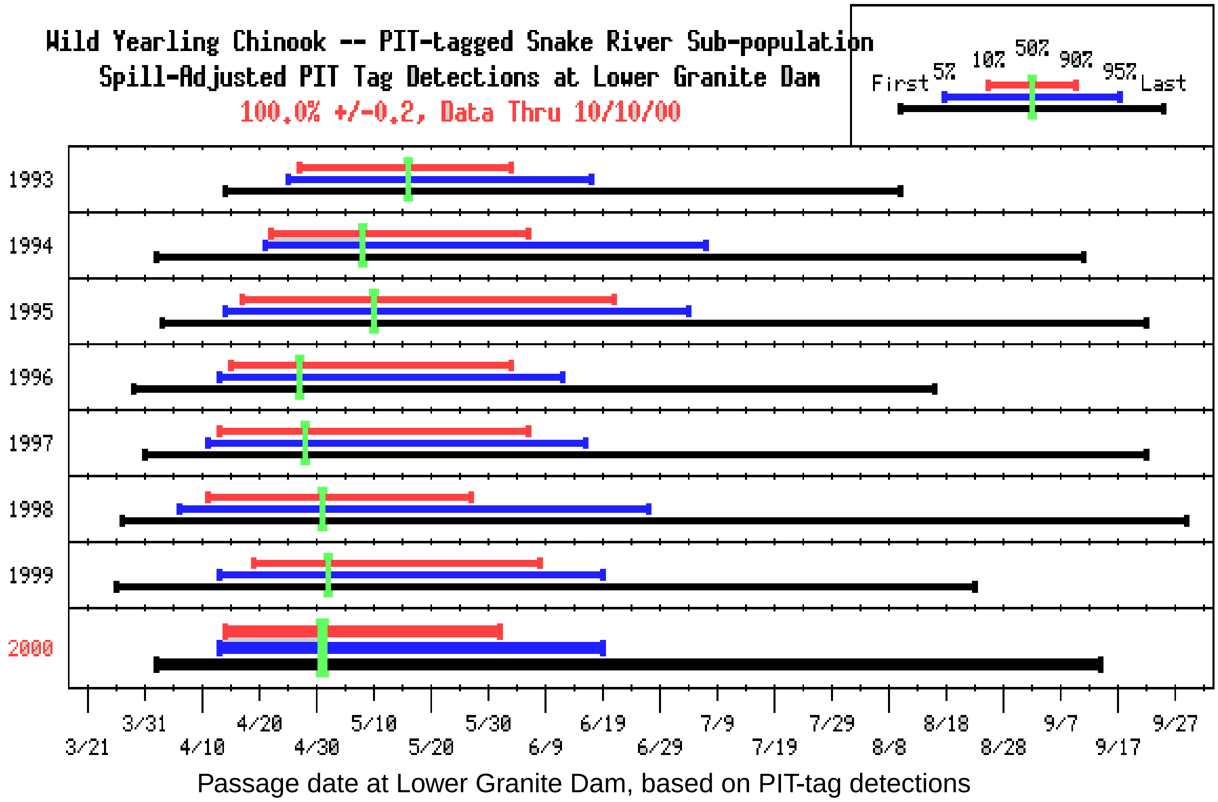
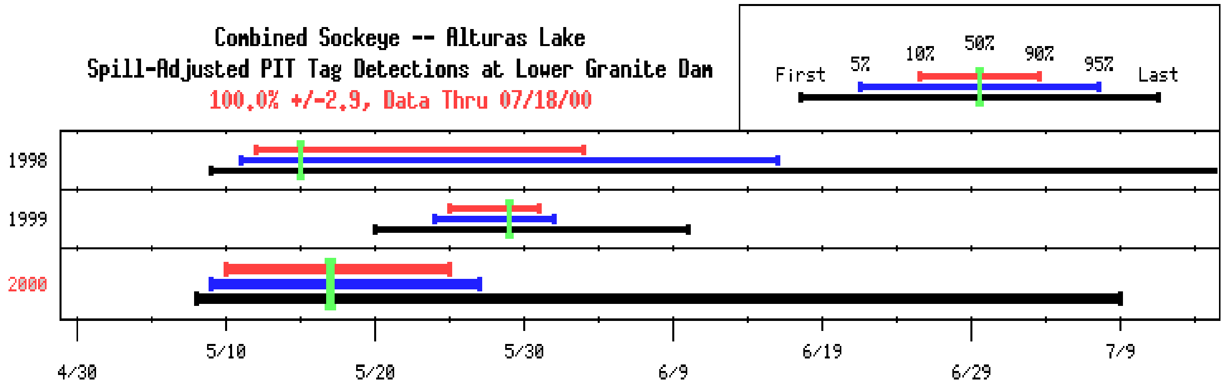


Table B20: Historical All-Wild PIT-tagged Yearling Chinook Salmon outmigration timing characteristics.

Year	Passage Dates							Duration Middle 80% (days)	Total LGR Passage
	First	5%	10%	50%	90%	95%	Last		
1993	04/14	04/25	04/27	05/16	06/03	06/17	08/10	38	3939
1994	04/02	04/21	04/22	05/08	06/06	07/07	09/11	46	6889
1995	04/03	04/14	04/17	05/10	06/21	07/04	09/22	66	9437
1996	03/29	04/13	04/15	04/27	06/03	06/12	08/16	50	5418
1997	03/31	04/11	04/13	04/28	06/06	06/16	09/22	55	2497
1998	03/27	04/06	04/11	05/01	05/27	06/27	09/29	47	13425
1999	03/26	04/13	04/19	05/02	06/08	06/19	08/23	51	17945
2000	04/02	04/13	04/14	05/01	06/01	06/19	09/14	49	14541

Figure B21: Historical Alturas Lake outmigration distribution at Lower Granite Dam.

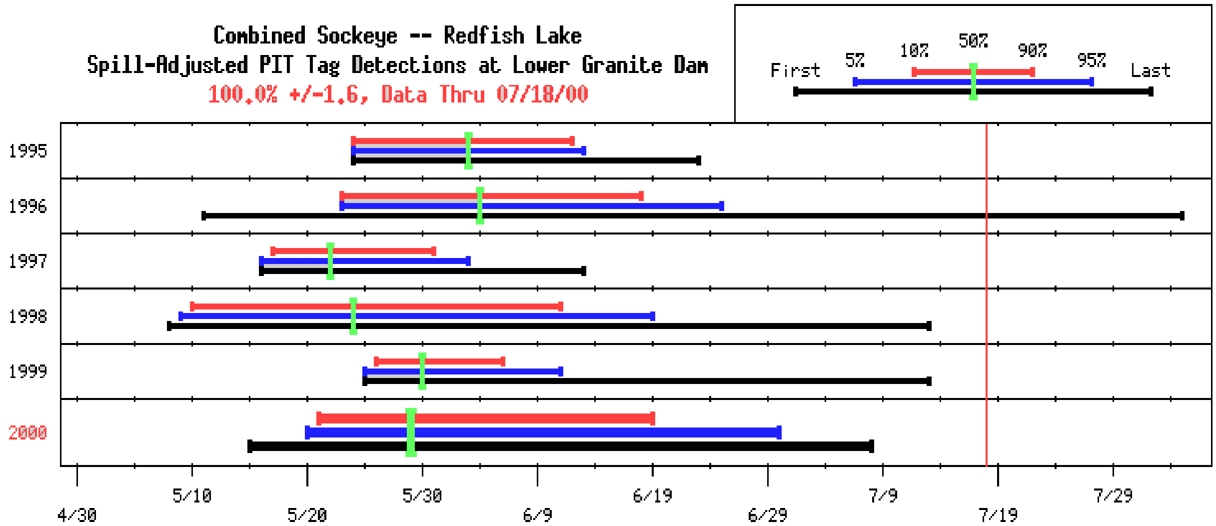


Passage date at Lower Granite Dam, based on PIT-tag detections

Table B21: Historical Alturas Lake outmigration timing characteristics.

Detection Year	Detection Dates							Middle 80% in days	Parr Released (1)	LWG PIT Counts (2)	Adjusted PIT Count (3)	Recovery % (3)/(1) x 100
	First	5%	10%	50%	90%	95%	Last					
1998	05/09	05/11	05/12	05/15	06/03	06/16	07/19	23	1860	220	423.2	22.8
1999	05/20	05/24	05/25	05/29	05/31	06/01	06/10	7	1246	140	350.3	28.1
2000	05/08	05/09	05/10	05/17	05/25	05/27	07/09	16	1554	117	222.3	14.3

Figure B22: Historical Redfish Lake outmigration distribution at Lower Granite Dam.



Passage date at Lower Granite Dam, based on PIT-tag detections

Table B22: Historical Redfish Lake outmigration timing characteristics.

Detection Year	Detection Dates							Middle 80% in days	Parr Released (1)	LWG PIT Counts (2)	Adjusted PIT Count (3)	Recovery % (3)/(1) x 100
	First	5%	10%	50%	90%	95%	Last					
1995	05/24	05/24	05/24	06/03	06/12	06/13	06/23	20	2728	20	26.6	1.0
1996	05/11	05/23	05/23	06/04	06/18	06/25	08/04	27	4246	160	377.8	8.9
1997	05/16	05/16	05/17	05/22	05/31	06/03	06/13	15	1930	53	131.2	6.8
1998	05/08	05/09	05/10	05/24	06/11	06/19	07/13	33	4692	71	145.6	3.1
1999	05/25	05/25	05/26	05/30	06/06	06/11	07/13	12	4179	58	143.9	3.4
2000	05/15	05/20	05/21	05/29	06/19	06/30	07/08	30	1557	42	80.5	5.2

Figure B23: Historical Wild PIT-tagged Subyearling Chinook Salmon (SNAKER) outmigration distribution at Lower Granite Dam.

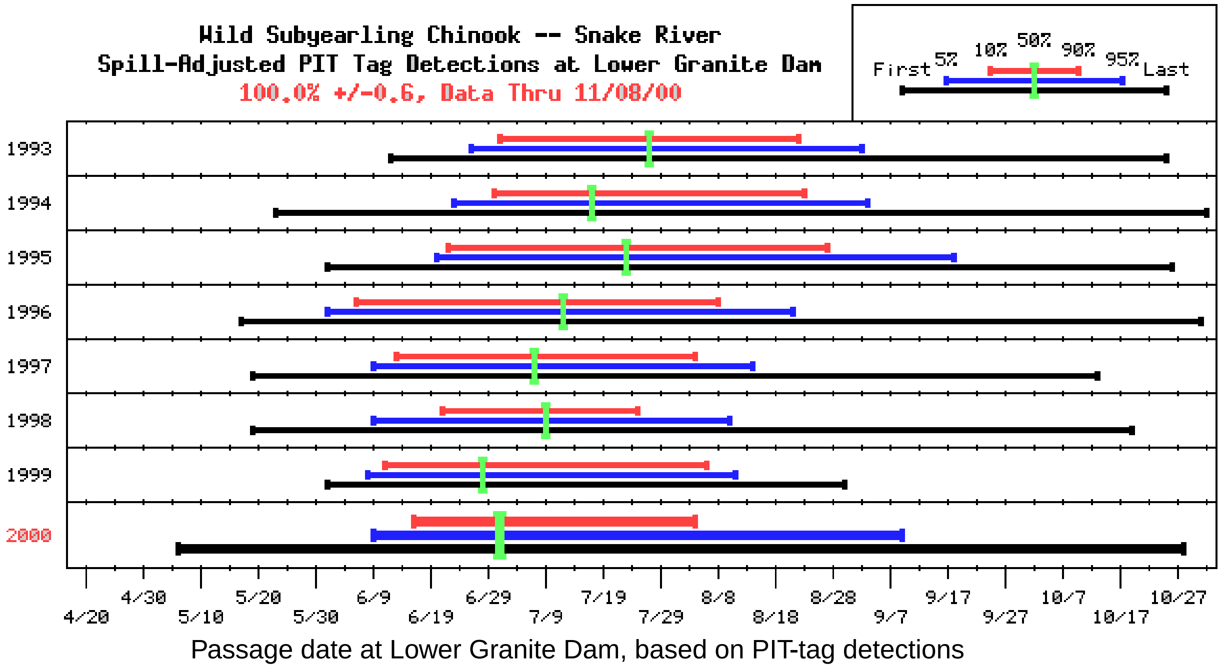


Table B23: Historical Wild PIT-tagged Subyearling Chinook Salmon (SNAKER) outmigration timing characteristics.

Detection Year	Detection Dates							Middle 80% in days	Parr Released (1)	LWG PIT Counts (2)	Adjusted PIT Count (3)	Recovery % (3)/(1) x 100
	First	5%	10%	50%	90%	95%	Last					
1993	06/12	06/26	07/01	07/27	08/22	09/02	10/25	53	1099	172	172.1	15.7
1994	05/23	06/23	06/30	07/17	08/23	09/03	11/01	55	2342	193	199.1	8.5
1995	06/01	06/20	06/22	07/23	08/27	09/18	10/26	67	1374	440	454.0	33.0
1996	05/17	06/01	06/06	07/12	08/08	08/21	10/31	64	463	146	186.1	40.2
1997	05/19	06/09	06/13	07/07	08/04	08/14	10/13	53	641	124	164.3	25.6
1998	05/19	06/09	06/21	07/09	07/25	08/10	10/19	35	2054	549	676.1	32.9
1999	06/01	06/08	06/11	06/28	08/06	08/11	08/30	57	1758	559	802.5	45.6
2000	05/06	06/09	06/16	07/01	08/04	09/09	10/28	50	1209	327	376.0	31.1

Figure B24: Historical All-Wild PIT-tagged Steelhead Trout outmigration distribution at Lower Granite dam.

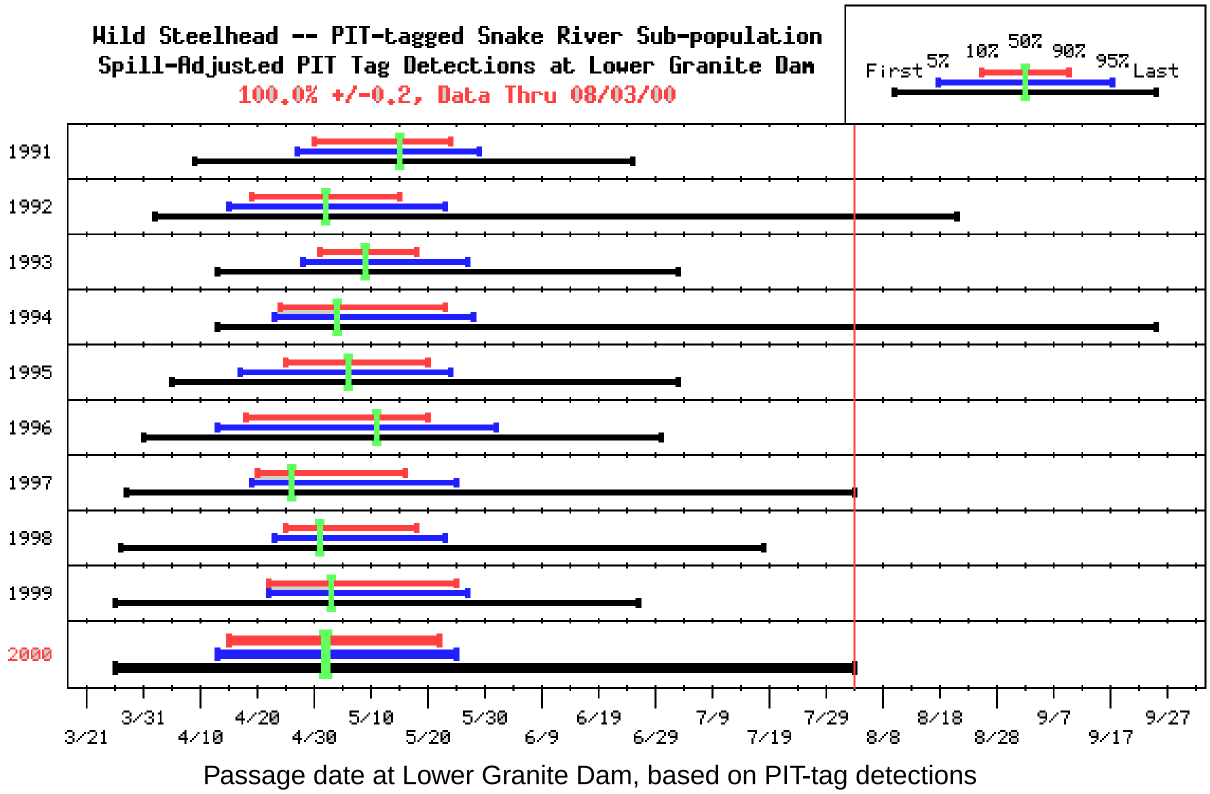


Table B24: Historical All-Wild PIT-tagged Steelhead Trout outmigration timing characteristics.

Year	Passage Dates							Duration Middle 80% (days)	Total LGR Passage
	First	5%	10%	50%	90%	95%	Last		
1991	04/09	04/27	04/30	05/15	05/24	05/29	06/25	25	2914
1992	04/02	04/15	04/19	05/02	05/15	05/23	08/21	27	3638
1993	04/13	04/28	05/01	05/09	05/18	05/27	07/03	18	4757
1994	04/13	04/23	04/24	05/04	05/23	05/28	09/25	30	5346
1995	04/05	04/17	04/25	05/06	05/20	05/24	07/03	26	4458
1996	03/31	04/13	04/18	05/11	05/20	06/01	06/30	33	3966
1997	03/28	04/19	04/20	04/26	05/16	05/25	08/03	27	4459
1998	03/27	04/23	04/25	05/01	05/18	05/23	07/18	24	8522
1999	03/26	04/22	04/22	05/03	05/25	05/27	06/26	34	6988
2000	03/26	04/13	04/15	05/02	05/22	05/25	08/03	38	13593

Figure B25: Historical Combined Wild and Hatchery Subyearling Chinook Salmon outmigration distribution at Rock Island Dam.

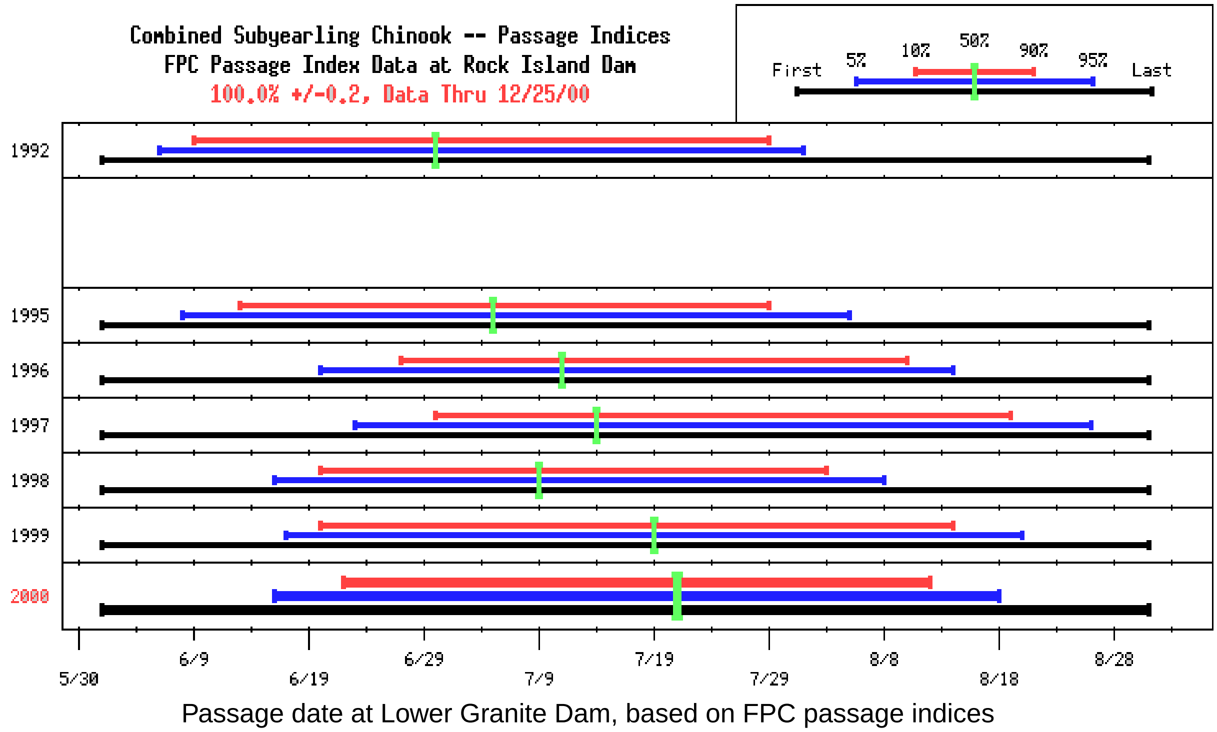


Table B25: Historical Combined Wild and Hatchery Subyearling Chinook Salmon outmigration timing characteristics at Rock Island Dam.

Year	Passage Dates							Duration Middle 80% (days)	Total LGR Passage
	First	5%	10%	50%	90%	95%	Last		
1992	06/01	06/06	06/09	06/30	07/29	08/01	08/31	51	10339
1995	06/01	06/08	06/13	07/05	07/29	08/05	08/31	47	14149
1996	06/01	06/20	06/27	07/11	08/10	08/14	08/31	45	15294
1997	06/01	06/23	06/30	07/14	08/19	08/26	08/31	51	19246
1998	06/01	06/16	06/20	07/09	08/03	08/08	08/31	45	17218
1999	06/01	06/17	06/20	07/19	08/14	08/20	08/31	56	28340
2000	06/01	06/16	06/20	07/10	08/07	08/12	8/31	52	13693

Figure B26: Historical Combined Wild and Hatchery Yearling Chinook Salmon outmigration distribution at Rock Island Dam.

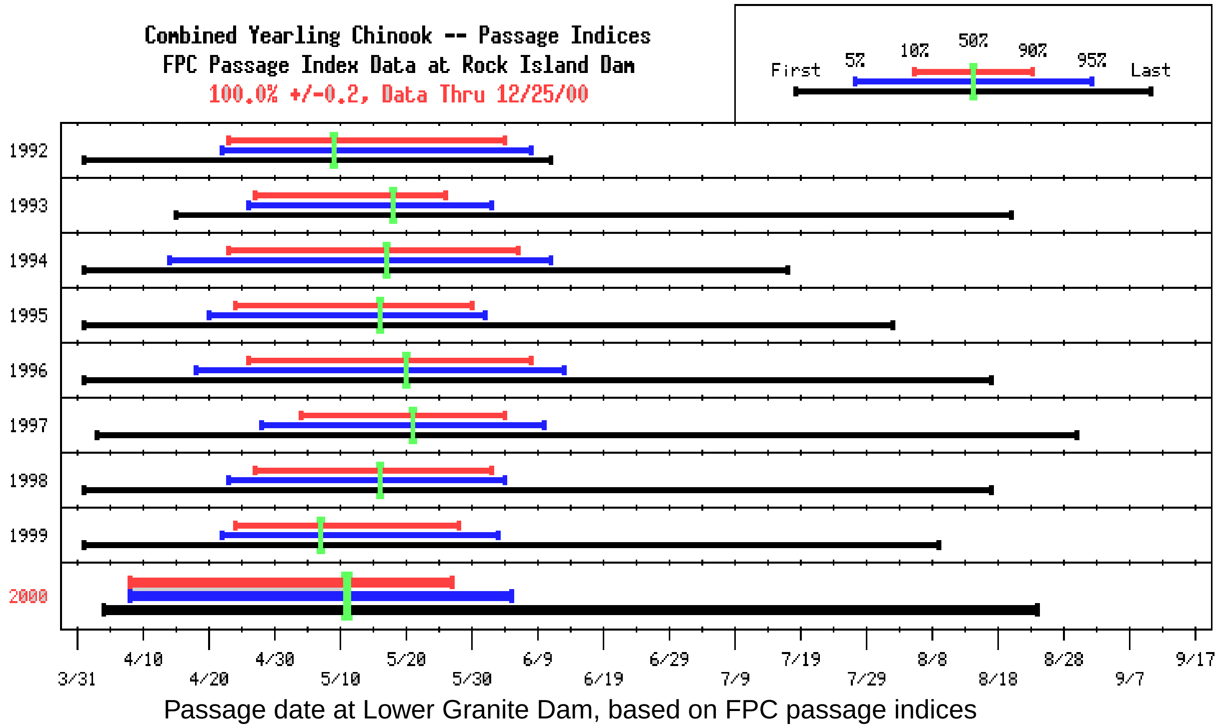


Table B26: Historical Combined Wild and Hatchery Yearling Chinook Salmon outmigration timing characteristics at Rock Island Dam..

Year	Passage Dates							Duration Middle 80% (days)	Total LGR Passage
	First	5%	10%	50%	90%	95%	Last		
1992	04/01	04/22	04/23	05/09	06/04	06/08	06/11	43	16100
1993	04/15	04/26	04/27	05/18	05/26	06/02	08/20	30	13514
1994	04/01	04/14	04/23	05/17	06/06	06/11	07/17	45	12324
1995	04/01	04/20	04/24	05/16	05/30	06/01	08/02	37	30753
1996	04/01	04/18	04/26	05/20	06/08	06/13	08/17	44	42478
1997	04/03	04/28	05/04	05/21	06/04	06/10	08/30	32	53754
1998	04/01	04/23	04/27	05/16	06/02	06/04	08/17	37	24859
1999	04/01	04/22	04/24	05/07	05/28	06/03	08/09	35	40320
2000	04/04	04/08	04/08	05/11	05/27	06/05	08/24	50	32334

Figure B27: Historical Combined Wild and Hatchery Coho Salmon outmigration distribution at Rock Island Dam.

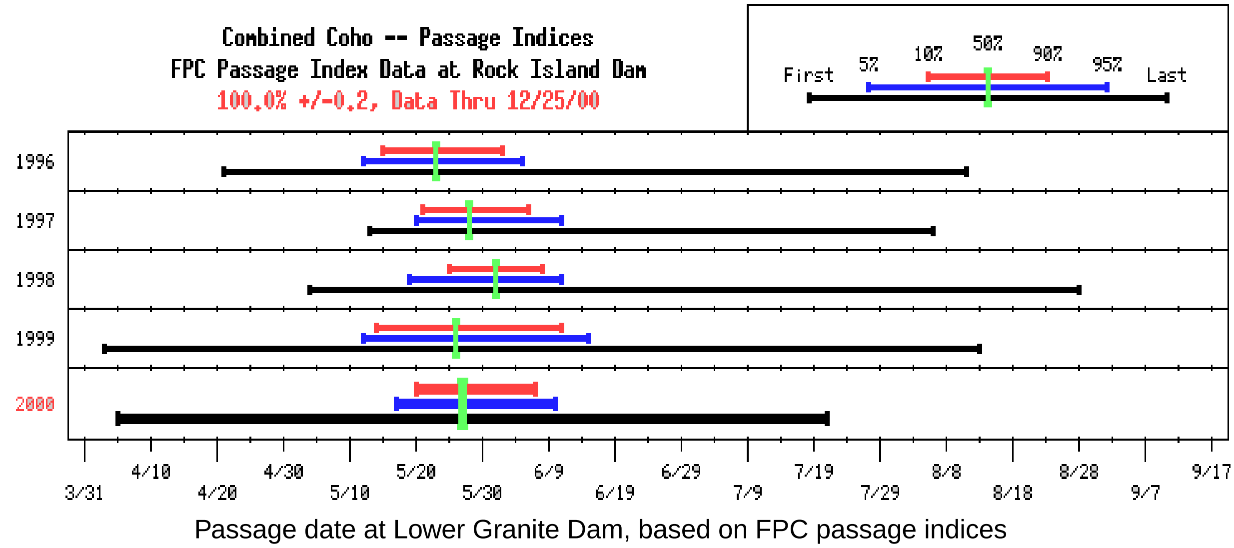


Table B27: Historical Combined Wild and Hatchery Coho Salmon outmigration timing characteristics at Rock Island Dam..

Year	Passage Dates							Duration Middle 80% (days)	Total LGR Passage
	First	5%	10%	50%	90%	95%	Last		
1996	04/21	05/12	05/15	05/23	06/02	06/05	08/11	19	26521
1997	05/13	05/20	05/21	05/28	06/06	06/11	08/06	17	4301
1998	05/04	05/19	05/25	06/01	06/08	06/11	08/28	15	41837
1999	04/03	05/12	05/14	05/26	06/11	06/15	08/13	29	46173
2000	04/05	05/17	05/20	05/27	06/07	06/10	07/21	19	49552

Figure B28: Historical Combined Wild and Hatchery Sockeye Salmon outmigration distribution at Rock Island Dam.

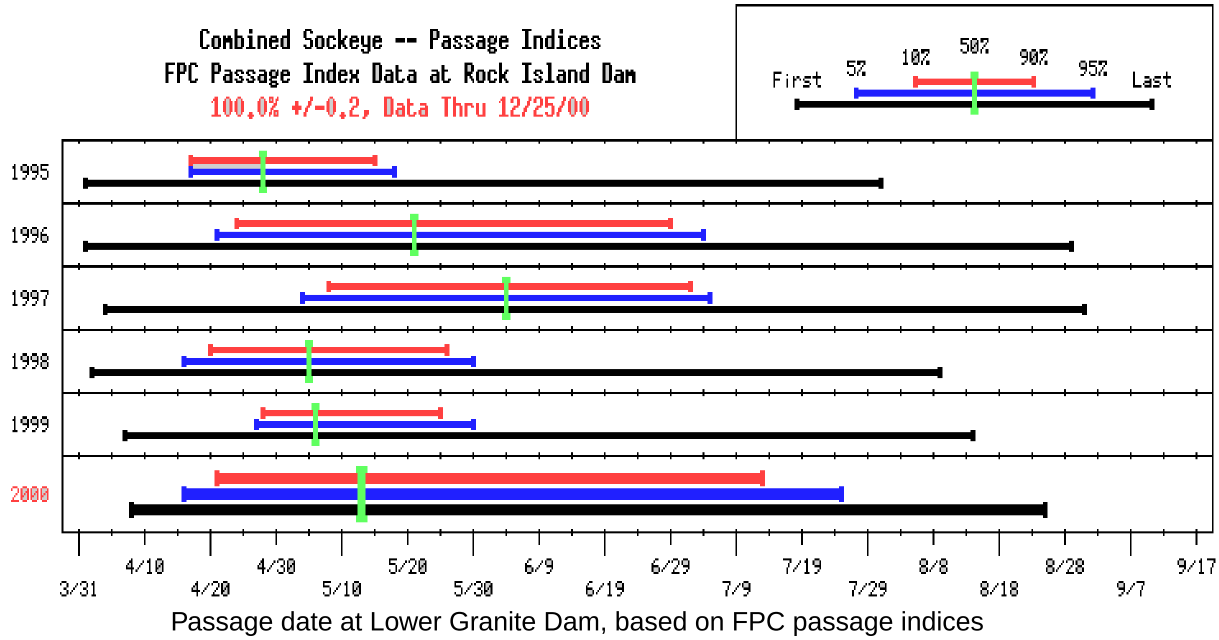
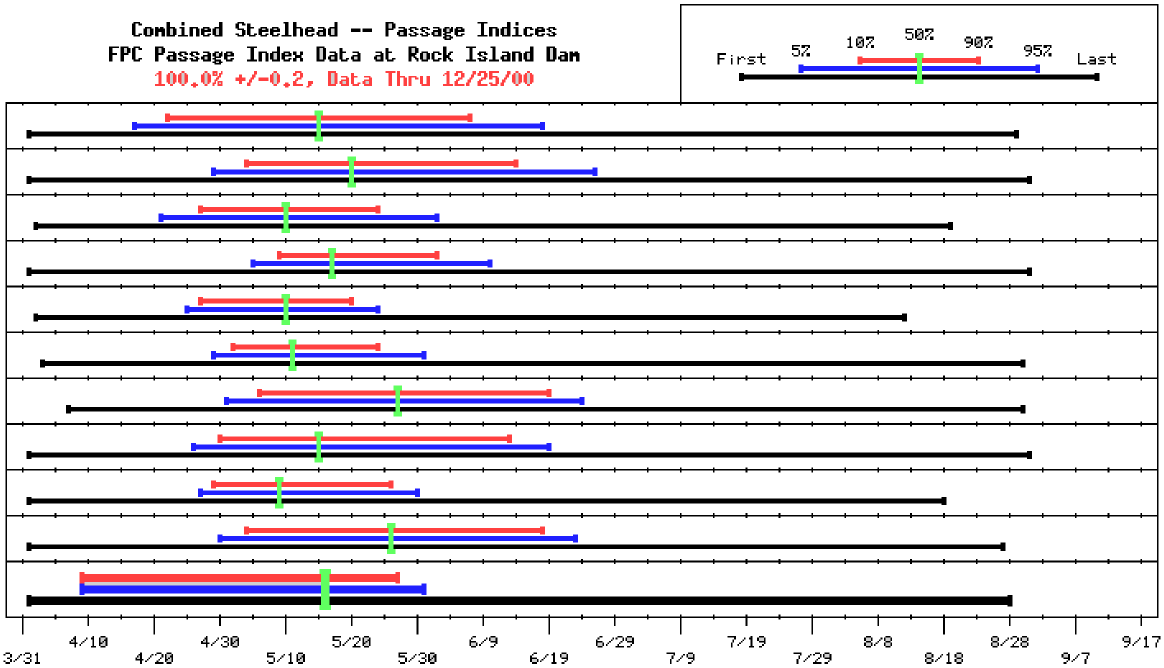


Table B28: Historical Combined Wild and Hatchery Sockeye Salmon outmigration timing characteristics at Rock Island Dam..

Year	Passage Dates							Duration Middle 80% (days)	Total LGR Passage
	First	5%	10%	50%	90%	95%	Last		
1995	04/01	04/17	04/17	04/28	05/15	05/18	07/31	29	27056
1996	04/01	04/21	04/24	05/21	06/29	07/04	08/29	67	9995
1997	04/04	05/04	05/08	06/04	07/02	07/05	08/31	56	13426
1998	04/02	04/16	04/20	05/05	05/26	05/30	08/09	37	16635
1999	04/07	04/27	04/28	05/06	05/25	05/30	08/14	28	23371
2000	04/08	04/16	04/21	05/13	07/13	07/25	08/25	84	2430

Figure B29: Historical Combined Wild and Hatchery Steelhead Trout outmigration distribution at Rock Island Dam.



Passage date at Lower Granite Dam, based on FPC passage indices

Table B29: Historical Combined Wild and Hatchery Steelhead Trout outmigration timing characteristics at Rock Island Dam..

Year	Passage Dates							Duration Middle 80% (days)	Total LGR Passage
	First	5%	10%	50%	90%	95%	Last		
1990	04/01	04/17	04/22	05/15	06/07	06/18	08/29	47	3739
1991	04/01	04/29	05/04	05/20	06/14	06/26	08/31	42	4953
1992	04/02	04/21	04/27	05/10	05/24	06/02	08/19	28	4906
1993	04/01	05/05	05/09	05/17	06/02	06/10	08/31	25	4032
1994	04/02	04/25	04/27	05/10	05/20	05/24	08/12	24	15323
1995	04/03	04/29	05/02	05/11	05/24	05/31	08/30	23	18084
1996	04/07	05/01	05/06	05/27	06/19	06/24	08/30	45	39650
1997	04/01	04/26	04/30	05/15	06/13	06/19	08/31	45	33979
1998	04/01	04/27	04/29	05/09	05/26	05/30	08/18	28	21390
1999	04/01	04/30	05/04	05/26	06/18	06/23	08/27	46	48192
2000	04/01	04/09	04/09	05/16	05/27	05/31	08/28	49	26297

Figure B30: Historical Combined Wild and Hatchery Subyearling Chinook Salmon outmigration distribution at McNary Dam.

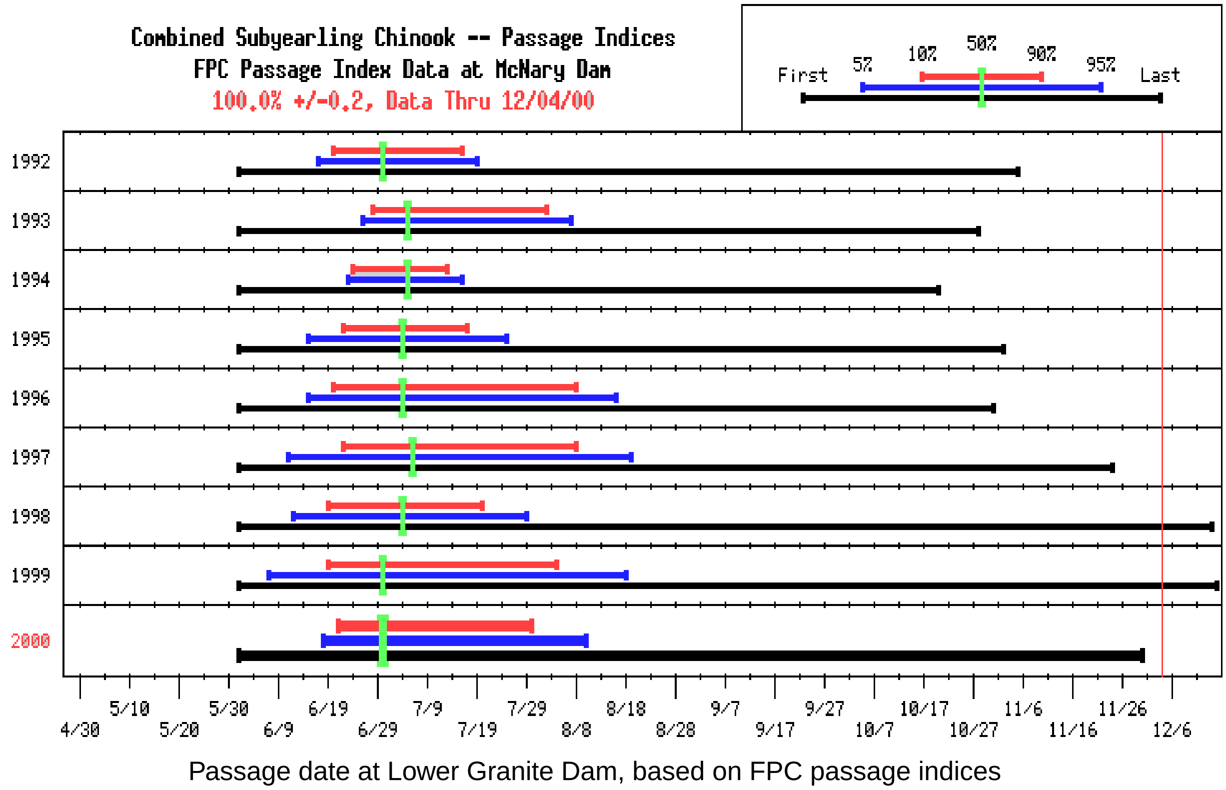


Table B30: Historical Combined Wild and Hatchery Subyearling Chinook Salmon outmigration timing characteristics at McNary Dam.

Year	Passage Dates							Duration Middle 80% (days)	Total LGR Passage
	First	5%	10%	50%	90%	95%	Last		
1992	06/01	06/17	06/20	06/30	07/16	07/19	11/05	27	6179484
1993	06/01	06/26	06/28	07/05	08/02	08/07	10/28	36	4283813
1994	06/01	06/23	06/24	07/05	07/13	07/16	10/20	20	5053511
1995	06/01	06/15	06/22	07/04	07/17	07/25	11/02	26	8223192
1996	06/01	06/15	06/20	07/04	08/08	08/16	10/31	50	6072944
1997	06/01	06/11	06/22	07/06	08/08	08/19	11/24	48	10383928
1998	06/01	06/12	06/19	07/04	07/20	07/29	12/14	32	11440908
1999	06/01	06/07	06/19	06/30	08/04	08/18	12/15	47	7645173
2000	06/01	06/18	06/21	06/30	07/30	08/10	11/30	41	10661814

Figure B31: Historical Combined Wild and Hatchery Yearling Chinook Salmon outmigration distribution at McNary Dam.

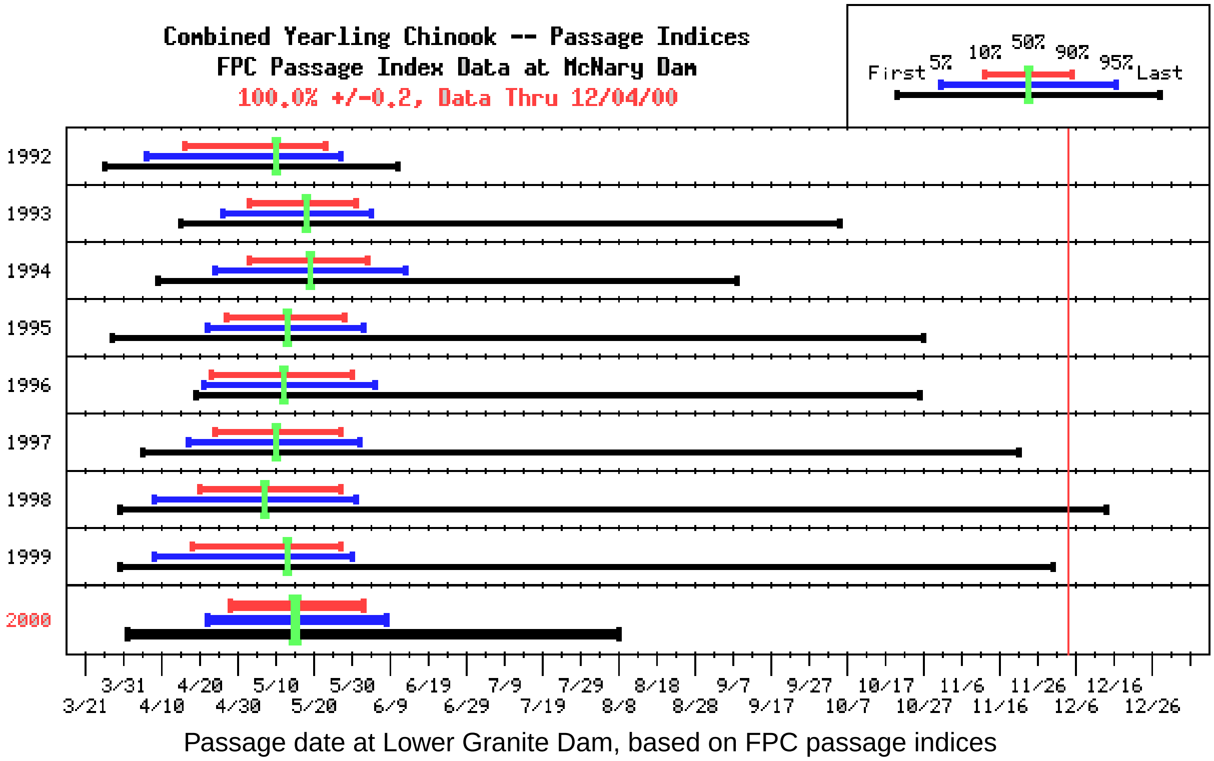


Table B31: Historical Combined Wild and Hatchery Yearling Chinook Salmon outmigration timing characteristics at McNary Dam.

Year	Passage Dates							Duration Middle 80% (days)	Total LGR Passage
	First	5%	10%	50%	90%	95%	Last		
1992	03/26	04/06	04/16	05/10	05/23	05/27	06/11	38	2514319
1993	04/15	04/26	05/03	05/18	05/31	06/04	10/05	29	1729010
1994	04/09	04/24	05/03	05/19	06/03	06/13	09/08	32	2572338
1995	03/28	04/22	04/27	05/13	05/28	06/02	10/27	32	2879069
1996	04/19	04/21	04/23	05/12	05/30	06/05	10/26	38	1240878
1997	04/05	04/17	04/24	05/10	05/27	06/01	11/21	34	1184530
1998	03/30	04/08	04/20	05/07	05/27	05/31	12/14	38	1727071
1999	03/30	04/08	04/18	05/13	05/27	05/30	11/30	40	3692944
2000	04/01	04/22	04/28	05/15	06/02	06/08	08/08	36	1986380

Figure B32: Historical Combined Wild and Hatchery Yearling Coho Salmon outmigration distribution at McNary Dam.

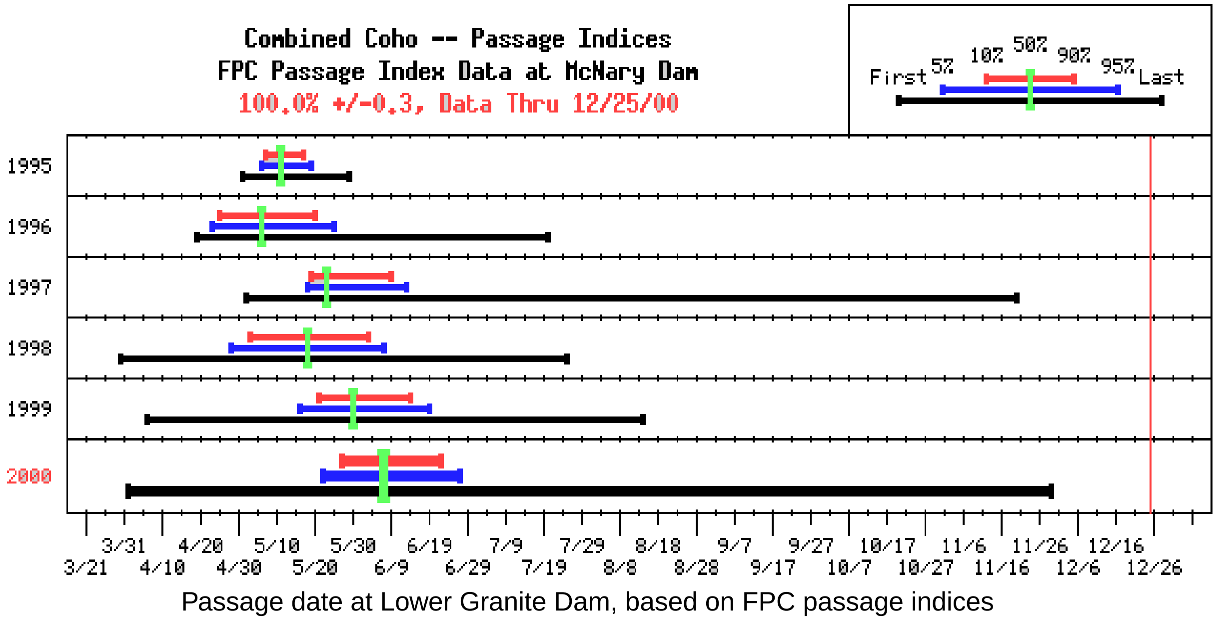


Table B32: Historical Combined Wild and Hatchery Yearling Coho Salmon outmigration timing characteristics at McNary Dam..

Year	Passage Dates							Duration Middle 80% (days)	Total LGR Passage
	First	5%	10%	50%	90%	95%	Last		
1995	05/01	05/06	05/07	05/11	05/17	05/19	05/29	11	236480
1996	04/19	04/23	04/25	05/06	05/20	05/25	07/20	26	647586
1997	05/02	05/18	05/19	05/23	06/09	06/13	11/20	22	339949
1998	03/30	04/28	05/03	05/18	06/03	06/07	07/25	32	241239
1999	04/06	05/16	05/21	05/30	06/14	06/19	08/14	25	281977
2000	04/01	05/22	05/27	06/07	06/22	06/27	11/29	27	260058

Figure B33: Historical Combined Wild and Hatchery Sockeye Salmon outmigration distribution at McNary Dam.

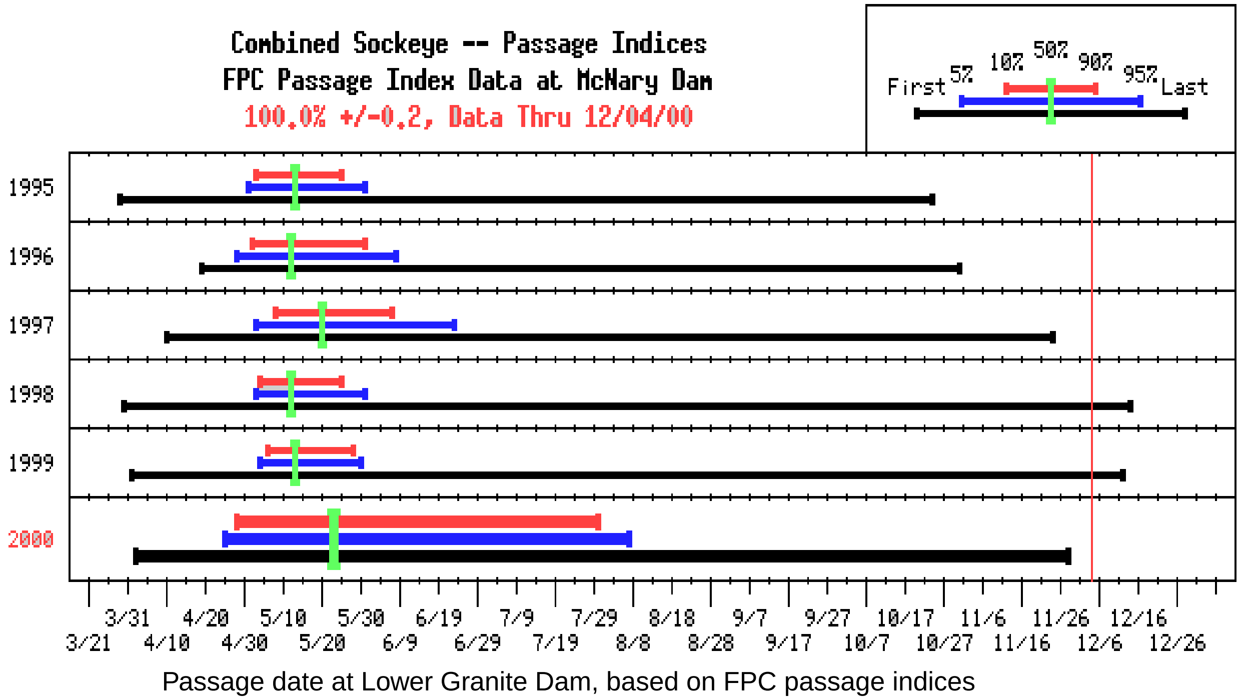


Table B33: Historical Combined Wild and Hatchery Sockeye Salmon outmigration timing characteristics at McNary Dam..

Year	Passage Dates							Duration Middle 80% (days)	Total LGR Passage
	First	5%	10%	50%	90%	95%	Last		
1995	03/29	05/01	05/03	05/13	05/25	05/31	10/24	23	1003494
1996	04/19	04/28	05/02	05/12	05/31	06/08	10/31	30	155094
1997	04/10	05/03	05/08	05/20	06/07	06/23	11/24	31	221166
1998	03/30	05/03	05/04	05/12	05/25	05/31	12/14	22	966549
1999	04/01	05/04	05/06	05/13	05/28	05/30	12/12	23	1446326
2000	04/02	04/25	04/28	05/23	07/30	08/08	11/30	94	139909

Figure B34: Historical Combined Wild and Hatchery Steelhead Trout outmigration distribution at McNary Dam.

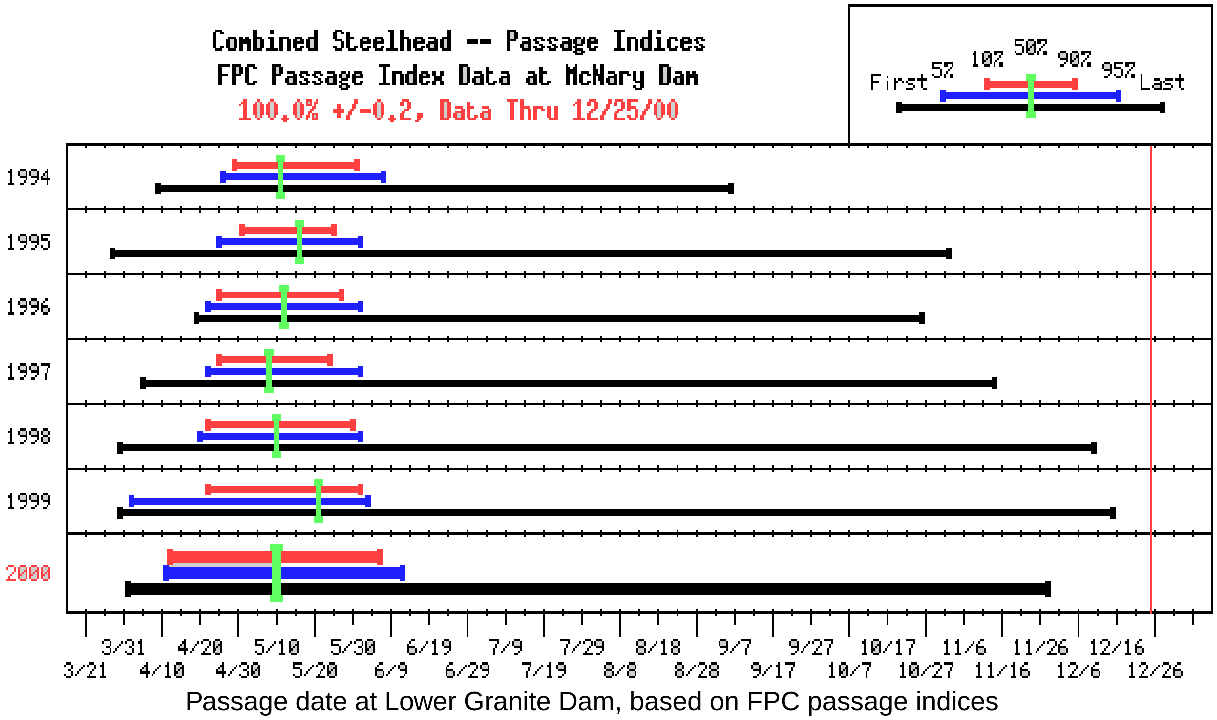


Table B34: Historical Combined Wild and Hatchery Steelhead Trout outmigration timing characteristics at McNary Dam..

Year	Passage Dates							Duration Middle 80% (days)	Total LGR Passage
	First	5%	10%	50%	90%	95%	Last		
1994	04/09	04/26	04/29	05/11	05/31	06/07	09/06	33	106520
1995	03/28	04/25	05/01	05/16	05/25	06/01	11/02	25	734878
1996	04/19	04/22	04/25	05/12	05/27	06/01	10/26	33	792462
1997	04/05	04/22	04/25	05/08	05/24	06/01	11/14	30	1234024
1998	03/30	04/20	04/22	05/10	05/30	06/01	12/10	39	571119
1999	03/30	04/02	04/22	05/21	06/01	06/03	12/15	41	1004348
2000	04/01	04/11	04/12	05/10	06/06	06/12	11/28	56	617482

Appendix C

Daily Expansion Factors for Spill-Adjusted PIT-Tagged Stocks Forecasted by Project RealTime in Migration Year 2000, including Spring/Summer Yearling Chinook Salmon Fall Subyearling Chinook Salmon and Summer Sockeye Salmon Stocks

Table C35: Migration year 2000 “expansion factors” for spill-adjusting the RealTime project’s PIT-tagged stocks (Section 2.3). These factors are multiplied by the number of PIT-detections (“raw” smolt counts) each day at Lower Granite Dam. The resulting “adjusted counts” (e.g., Table 2) estimate the daily combined smolts detected in the PIT-detection system and smolts passing undetected through the spillway. (Factors are computed as 1/(1-SE), where SE is equal to spill effectiveness, defined in eqn. 1 of text for chinook and sockeye salmon (column 2) and in eqn. 2 for steelhead trout (column 3).)

DATE	Expansion Factors for Chinook and Sockeye Salmon	Expansion Factors for Steelhead Trout
4/1	0.00	0.00
4/2	0.00	0.00
4/3	0.03	0.01
4/4	0.00	0.00
4/5	0.15	0.13
4/6	0.01	0.00
4/7	0.37	0.33
4/8	0.60	0.51
4/9	0.60	0.51
4/10	0.59	0.51
4/11	0.46	0.41
4/12	0.47	0.41
4/13	0.46	0.40
4/14	0.45	0.40
4/15	0.49	0.43
4/16	0.46	0.40
4/17	0.46	0.41
4/18	0.46	0.40
4/19	0.45	0.39

DATE	Expansion Factors for Chinook and Sockeye Salmon	Expansion Factors for Steelhead Trout
4/20	0.46	0.40
4/21	0.47	0.41
4/22	0.46	0.41
4/23	0.64	0.56
4/24	0.51	0.44
4/25	0.45	0.40
4/26	0.46	0.41
4/27	0.46	0.41
4/28	0.46	0.41
4/29	0.47	0.41
4/30	0.46	0.40
5/1	0.46	0.41
5/2	0.46	0.40
5/3	0.46	0.40
5/4	0.46	0.41
5/5	0.46	0.40
5/6	0.46	0.40
5/7	0.47	0.41
5/8	0.48	0.42

Table C35: Migration year 2000 "expansion factors" for spill-adjusting the RealTime project's PIT-tagged stocks (Section 2.3). These factors are multiplied by the number of PIT-detections ("raw" smolt counts) each day at Lower Granite Dam. The resulting "adjusted counts" (e.g., Table 2) estimate the daily combined smolts detected in the PIT-detection system and smolts passing undetected through the spillway. (Factors are computed as 1/(1-SE), where SE is equal to spill effectiveness, defined in eqn. 1 of text for chinook and sockeye salmon (column 2) and in eqn. 2 for steelhead trout (column 3).)

DATE	Expansion Factors for Chinook and Sockeye Salmon	Expansion Factors for Steelhead Trout
5/9	0.47	0.41
5/10	0.47	0.41
5/11	0.47	0.41
5/12	0.48	0.42
5/13	0.48	0.42
5/14	0.47	0.41
5/15	0.48	0.42
5/16	0.49	0.43
5/17	0.49	0.43
5/18	0.47	0.41
5/19	0.47	0.41
5/20	0.47	0.42
5/21	0.47	0.41
5/22	0.47	0.41
5/23	0.45	0.40
5/24	0.46	0.40
5/25	0.45	0.40
5/26	0.45	0.40
5/27	0.45	0.40
5/28	0.45	0.40

DATE	Expansion Factors for Chinook and Sockeye Salmon	Expansion Factors for Steelhead Trout
5/29	0.54	0.47
5/30	0.57	0.49
5/31	0.60	0.51
6/1	0.61	0.52
6/2	0.64	0.55
6/3	0.66	0.57
6/4	0.65	0.57
6/5	0.62	0.54
6/6	0.60	0.51
6/7	0.59	0.51
6/8	0.60	0.52
6/9	0.65	0.56
6/10	0.67	0.58
6/11	0.68	0.59
6/12	0.68	0.59
6/13	0.64	0.56
6/14	0.62	0.53
6/15	0.62	0.53
6/16	0.61	0.53
6/17	0.64	0.56

Table C35: Migration year 2000 "expansion factors" for spill-adjusting the RealTime project's PIT-tagged stocks (Section 2.3). These factors are multiplied by the number of PIT-detections ("raw" smolt counts) each day at Lower Granite Dam. The resulting "adjusted counts" (e.g., Table 2) estimate the daily combined smolts detected in the PIT-detection system and smolts passing undetected through the spillway. (Factors are computed as 1/(1-SE), where SE is equal to spill effectiveness, defined in eqn. 1 of text for chinook and sockeye salmon (column 2) and in eqn. 2 for steelhead trout (column 3).)

DATE	Expansion Factors for Chinook and Sockeye Salmon	Expansion Factors for Steelhead Trout
6/18	0.68	0.59
6/19	0.68	0.59
6/20	0.47	0.41
6/21	0.00	0.00
6/22	0.00	0.00
6/23	0.00	0.00
6/24	0.00	0.00
6/25	0.00	0.00
6/26	0.00	0.00
6/27	0.00	0.00
6/28	0.00	0.00
6/29	0.00	0.00
6/30	0.00	0.00
7/1	0.00	0.00
7/2	0.00	0.00
7/3	0.00	0.00
7/4	0.00	0.00
7/5	0.00	0.00
7/6	0.00	0.00
7/7	0.00	0.00

DATE	Expansion Factors for Chinook and Sockeye Salmon	Expansion Factors for Steelhead Trout
7/8	0.00	0.00
7/9	0.00	0.00
7/10	0.00	0.00
7/11	0.00	0.00
7/12	0.00	0.00
7/13	0.00	0.00
7/14	0.00	0.00
7/15	0.00	0.00
7/16	0.00	0.00
7/17	0.00	0.00
7/18	0.00	0.00
7/19	0.00	0.00
7/20	0.00	0.00
7/21	0.00	0.00
7/22	0.00	0.00
7/23	0.00	0.00
7/24	0.00	0.00
7/25	0.00	0.00
7/26	0.00	0.00
7/27	0.00	0.00

Table C35: Migration year 2000 "expansion factors" for spill-adjusting the RealTime project's PIT-tagged stocks (Section 2.3). These factors are multiplied by the number of PIT-detections ("raw" smolt counts) each day at Lower Granite Dam. The resulting "adjusted counts" (e.g., Table 2) estimate the daily combined smolts detected in the PIT-detection system and smolts passing undetected through the spillway. (Factors are computed as 1/(1-SE), where SE is equal to spill effectiveness, defined in eqn. 1 of text for chinook and sockeye salmon (column 2) and in eqn. 2 for steelhead trout (column 3).)

DATE	Expansion Factors for Chinook and Sockeye Salmon	Expansion Factors for Steelhead Trout
7/28	0.00	0.00
7/29	0.00	0.00
7/30	0.00	0.00
7/31	0.00	0.00
8/1	0.00	0.00
8/2	0.00	0.00
8/3	0.00	0.00
8/4	0.00	0.00
8/5	0.00	0.00
8/6	0.00	0.00
8/7	0.00	0.00
8/8	0.00	0.00
8/9	0.00	0.00
8/10	0.00	0.00
8/11	0.00	0.00
8/12	0.00	0.00
8/13	0.00	0.00
8/14	0.00	0.00
8/15	0.00	0.00
8/16	0.00	0.00

DATE	Expansion Factors for Chinook and Sockeye Salmon	Expansion Factors for Steelhead Trout
8/17	0.00	0.00
8/18	0.00	0.00
8/19	0.00	0.00
8/20	0.00	0.00
8/21	0.00	0.00
8/22	0.00	0.00
8/23	0.00	0.00
8/24	0.00	0.00
8/25	0.00	0.00
8/26	0.00	0.00
8/27	0.00	0.00
8/28	0.00	0.00
8/29	0.00	0.00
8/30	0.00	0.00
8/31	0.00	0.00
9/1	0.00	0.00
9/2	0.00	0.00
9/3	0.00	0.00
9/4	0.00	0.00
9/5	0.00	0.00

Table C35: Migration year 2000 "expansion factors" for spill-adjusting the RealTime project's PIT-tagged stocks (Section 2.3). These factors are multiplied by the number of PIT-detections ("raw" smolt counts) each day at Lower Granite Dam. The resulting "adjusted counts" (e.g., Table 2) estimate the daily combined smolts detected in the PIT-detection system and smolts passing undetected through the spillway. (Factors are computed as 1/(1-SE), where SE is equal to spill effectiveness, defined in eqn. 1 of text for chinook and sockeye salmon (column 2) and in eqn. 2 for steelhead trout (column 3).)

DATE	Expansion Factors for Chinook and Sockeye Salmon	Expansion Factors for Steelhead Trout
9/6	0.00	0.00
9/7	0.00	0.00
9/8	0.00	0.00
9/9	0.00	0.00
9/10	0.00	0.00
9/11	0.00	0.00
9/12	0.00	0.00
9/13	0.00	0.00
9/14	0.00	0.00
9/15	0.00	0.00
9/16	0.00	0.00
9/17	0.00	0.00
9/18	0.00	0.00
9/19	0.00	0.00
9/20	0.00	0.00
9/21	0.00	0.00
9/22	0.00	0.00
9/23	0.00	0.00
9/24	0.00	0.00
9/25	0.00	0.00

DATE	Expansion Factors for Chinook and Sockeye Salmon	Expansion Factors for Steelhead Trout
9/26	0.00	0.00
9/27	0.00	0.00
9/28	0.00	0.00
9/29	0.00	0.00
9/30	0.00	0.00
10/1	0.00	0.00
10/2	0.00	0.00
10/3	0.00	0.00
10/4	0.00	0.00
10/5	0.00	0.00
10/6	0.00	0.00
10/7	0.00	0.00
10/8	0.00	0.00
10/9	0.00	0.00
10/10	0.76	0.68
10/11	0.84	0.78
10/12	0.00	0.00
10/13	0.00	0.00
10/14	0.00	0.00
10/15	0.00	0.00

Table C35: Migration year 2000 “expansion factors” for spill-adjusting the RealTime project’s PIT-tagged stocks (Section 2.3). These factors are multiplied by the number of PIT-detections (“raw” smolt counts) each day at Lower Granite Dam. The resulting “adjusted counts” (e.g., Table 2) estimate the daily combined smolts detected in the PIT-detection system and smolts passing undetected through the spillway. (Factors are computed as 1/(1-SE), where SE is equal to spill effectiveness, defined in eqn. 1 of text for chinook and sockeye salmon (column 2) and in eqn. 2 for steelhead trout (column 3).)

DATE	Expansion Factors for Chinook and Sockeye Salmon	Expansion Factors for Steelhead Trout
10/16	0.00	0.00
10/17	0.00	0.00
10/18	0.00	0.00
10/19	0.00	0.00
10/20	0.00	0.00
10/21	0.00	0.00
10/22	0.00	0.00
10/23	0.00	0.00
10/24	0.00	0.00
10/25	0.00	0.00
10/26	0.00	0.00
10/27	0.00	0.00
10/28	0.00	0.00
10/29	0.00	0.00
10/30	0.00	0.00
10/31	0.00	0.00